

Revised 12/03

CORRES. CONTROL
INCOMING LTR NO.

00173 RFOY

DUE DATE

ACTION

RECEIVED

2004 APR 13 A 6:50 Department of Energy

CORRESPONDENCE
CONTROL

ROCKY FLATS PROJECT OFFICE
10808 HIGHWAY 93, UNIT A
GOLDEN, COLORADO 80403-8200

04-DOE-00275



DIST.	LTR	ENC
BERARDINI, J.H.	X	X
BOGNAR, E.S.	X	X
BROOKS, L.	X	X
BUTLER, L.	X	X
CARPENTER, M.	X	X
CROCKETT, G. A.	X	X
DECK, C. A.	X	X
DEGENHART, K. R.	X	X
DIETER, T. J.		
DIETERLE, S. E.		
FERRERA, D. W.	X	X
GIACOMINI, J. J.		
LINDSAY, D. C.	X	X
LONG, J. W.		
LYLE, J. L.		
MARTINEZ, L. A.	X	X
NAGEL, R. E.	X	X
NESTA, S.	X	X
NORTH, K.	X	X
PARKER, A. M.	X	X
RODGERS, A. D.		
SHELTON, D. C.	X	X
SPEARS, M. S.		
PIZZUTO, V.		
TUOR, N. R.	X	X
WIEMELT, K.		
WILLIAMS, J. L.		
ZAHM, C.	X	X
TODD, M.	X	X
PARSONS, D.	X	X
FLOSS, D.	X	X
BURCH, M.	X	X

COR. CONTROL	X	X
ADMIN. RECORD	X	X
PATS/130		

Reviewed for Addressee
Corres. Control RFP

4/13/04
Date By

Ref. Ltr. #

DOE ORDER #

5400.1

Mr. Steven H. Gunderson
Rocky Flats Cleanup Agreement Project Coordinator
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Dear Mr. Gunderson:

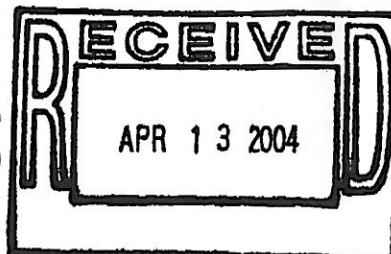
Please find the Facility Disposition Rocky Flats Cleanup Agreement Standard Operating Protocol (RSOP) Notification letter for the Type 2 Facilities Building 881, 881F, and 887. This notification invokes the RSOP for demolition of the facility pending completion and Lead Regulatory Agency concurrence of the Pre-Demolition Survey Report (PDSR) for the facility and the enclosed documents:

1. The demolition method analysis of choosing demolition with explosives over mechanical demolition methods (Enclosure I).
2. A strategy for the demolition approach (demolition plan) using explosives (Enclosure II). A proprietary work plan for explosives is available for review in Dyan Foss's Office, (303) 966-7577.
3. The Reconnaissance Level Characterization Report was approved on December 20, 2001.
4. The level one schedule is Enclosure IV.
5. Stakeholder briefings and discussion were held at the Environmental Restoration/Decontamination and Demolition meetings on October 21, 2003, January 20, 2004, and one final presentation is scheduled for May 18, 2004.
6. A contact record on April 1, 2004, titled "Demolition of Appurtenances", detailed the demolition of the north-side plenum area to facilitate boring of vertical holes in exterior walls and the south-side dock area to facilitate removal of block wall debris.
7. The structural analysis is also available for information, i.e. the structural weakening of the building prior to use of explosives. Note that the U.S. Department of Energy (DOE) will have an independent licensed structural engineer review this analysis.
8. The strategy deviates from the standard RSOP for recycled concrete in size. The Building 881 backfill will follow the same strategy as the Building 771 plan for mix and compaction. This blending and compression should alleviate any significant concerns for voids. The DOE concurs in this strategy as it will utilize the Building 850 concrete pile, which if not utilized for Building 881 will be hauled to a landfill.

*Document, including attachments,
is unclassified, not UCN, and
not ORO. Public release OK.*

DOCUMENT CLASSIFICATION
REVIEW WAIVER PER
CLASSIFICATION OFFICE

*JAN 13 2004
Enclosure Class
Office
10-06-08*



ADMIN RECORD

B881-A-000039

Mr. Steven H. Gunderson
04-DOE-00275

2

Note that a separate PDSR letter will be forthcoming on or about April 22, 2004. Questions may be directed to Gary P. Morgan, HQPM at (303) 966-6003.

Sincerely,



Joseph A. Legare, Director
RFPO Project Management Division

Enclosures

cc w/o Encls.:

M. Swartz, K-H, RISS D&D
D. Foss, K-H, RISS D&D
D. Parsons, K-H, RISS D&D
S. Nesta, K-H RISS D&D
M. Aguilar, USEPA
Administrative Record

cc w/Encls.:

F. Lockhart, OOM, RFPO

Attachment I
Evaluation of Demolition Methods for Building 881

DOES NOT CONTAIN
OFFICIAL USE ONLY INFORMATION

Name/Org

Edmore Corporation

Date

10/6/08

OK for public release

EVALUATION DEMOLITION METHODS FOR BUILDING 881

1. Introduction

This evaluation appraises the potential methods for the demolition of Building 881 at the Rocky Flats Environmental Technology Site (RFETS). The approaches to the Building 881 demolition were evaluated based on input from demolition subcontractors. The demolition subcontractors were asked to evaluate Building 881 and propose the safest and most efficient means for demolition. The methods evaluated include mechanical demolition to include excavators with attachments and demolition using explosives. It should be noted that all of contractors recommended demolition with explosives due to the size and construction of Building 881

The mechanical means of demolition evaluated for Building 881 was excavator with attachments. The wrecking ball method of demolition was not evaluated because the method is difficult to control from a health and safety and dust perspective. Cabling was not evaluated because this method would not work on a structure of this size and construction. Non-explosive cracking agent was not evaluated because it is generally used on horizontal surfaces and small areas. Diamond wire cutting was not evaluated because it would involve extensive hoisting and rigging.

2. Evaluation Scope

The evaluation only includes demolition activities for Building 881. Activities before and after demolition are the same regardless of the demolition method. The purpose of the evaluation is to determine which of the methods are viable for demolition of the Building 881. The evaluations developed by the individual subject matter experts are subjective and based on their years of experience. While many methods were considered, only a few were evaluated completely. For example, use of a wrecking ball was considered but not evaluated based on the inherent safety concerns, increased fugitive emissions, and increased amount of runoff generation due to dust suppression efforts. The methods evaluated are viable means for demolition of the structure, but certain aspects of each method may be preferable over the other methods. This evaluation was not used to determine the demolition method for the subject structure; the evaluation documents the process of the determination on the demolition method.

2.1. Building 881

Building 881 is a rectangular, concrete three-story structure encompassing approximately 245,160 square feet. It has 17,870 square feet in the basement, 86,300 square feet on the first floor, 6,000 square feet on the first floor mezzanine, 121,460 square feet on the second floor, and 13,530 square feet on the second floor mezzanine. Additionally, there are two rooftop structures, supply and exhaust filter plenums, 3,600 and 9,470 square feet, respectively. Four additions have been built since the original construction in 1952:

- 1956, a two story Annex, 31,600 square feet including supply and exhaust ventilation and a stack added to the northwest corner to provide additional machining capability. Additionally, several radiography vaults were added in the northeast corner of the structure
- 1969, the pressure test facility was added on the east side

- 1986, the new two-stage, HEPA exhaust filter building was built on the roof of the existing structure, and an exhaust chase was added to the east side to bypass the original single-stage exhaust filters

Building 881 is a large multi-story building constructed of cast concrete walls, columns, and ceilings erected on spread footings with reinforced concrete beams. The main foundations of the building are individual spread footings of concrete for the interior columns and continuous footings of concrete for the exterior walls. The spread footings have a maximum size of 11-feet-square by 2-1/2-feet-thick, and the minimum size of 4-feet-square by 1-foot thick. The structure is reinforced concrete columns and cast concrete walls and floors. The continuous footings vary from 10- to 16-inches thick. The building is partially built into the hillside, with the roof being approximately the same elevation as the grade of the northwest corner. The structure is designed to withstand forces considerably above normal static loading based on defense mission design requirements.

The north and west walls of the building are built into the hillside descending to three feet below the floor level at the south dock. There are two loading docks on the east side, also built into the hillside and a number of retaining walls. The roof is covered with rigid insulation material and membrane roofing.

3. Evaluation Summary

Table 1 contains the demolition method evaluation for the Building 881 with explosives versus mechanical means. The following sections summarize the results of the evaluation of demolition techniques for Building 881. In addition, each section indicates the preferred method for demolition with respect to the criteria. This evaluation documents why explosives were chosen as the demolition method for Building 881.

3.1. Health and Safety Evaluation

A safety professional developed the activities, hazards, and controls associated with each method of demolition, and using that information, determined the positive and negative aspects of each method from a health and safety perspective. From a health and safety perspective, all of the hazards can be controlled thereby reducing the risk, which is why the methods are evaluated without the controls. The demolition method using explosives has a significantly shorter duration, statistically lowering the potential for incidents, and that is why that method is preferred.

3.2. Environmental

An environmental subject matter expert outlined the potential impacts associated with each method of demolition, and using that information, determined the positive and negative aspects of each method from an environmental perspective. In general, the demolition method involving explosives had more positive/acceptable impacts than mechanical demolition. The categories that differentiated the methods were soils and geology, air quality, water quality, human health and safety, and noise. The primary reason the methods involving explosives had more positive/acceptable impacts was primarily due to the decreased duration of project activities. Neither method has significant environmental impacts.

3.3. Structural

An engineer evaluated the effectiveness of each method of demolition, and using that information, determined the positive and negative aspects of the effectiveness of the each method. The structural evaluation indicates that all of the demolition methods evaluated are viable demolition techniques. The explosive method evaluated better than the other method because it did not require accounting for the soil load. Overall, the explosive demolition method is the most efficient.

3.4. Economic

The economic evaluation was based on estimates provided by demolition subcontractors. The cost and duration for mechanical demolition are presented as ranges because there are unknown associated with the soil removal and accounting for multiple handling of the debris. The cost of backfilling after demolition were not included due to those costs being required and necessary regardless of method used. The economic evaluation indicates that explosive demolition is the most cost-effective method.

Table 1. Demolition Evaluation¹

Project Description ²	Mechanical Demolition	Explosive Demolition
<p>The initial objective during demolition would be to remove structures and appurtenances connected and adjacent to the primary Building 881 structure to allow unrestricted access to that structure. Additionally, the filter plenum and supplied air units would be removed from the roof of the building. Removal of these features exposes the main structure and allows access to the elevated portions of Building 881.</p> <p>At the same time, soil would be moved away from behind the north and west building and retaining walls of Building 881 down to an elevation approximately eight feet below the top of the north wall. Removal of the soil would relieve passive earth loading pressure from the top section of the wall and allow for the safe removal of the roof framing system and upper section of the walls. Demolition would leave as much of these walls in place as possible. The objective of the soil removal and demolition of the upper wall section is to leave the area in a safe configuration until the site is backfilled during site restoration.</p> <p>The demolition approach would follow the overall approach of working off the existing first floor slab elevation and collapsing demolition materials and debris into and onto the surface for segregation and dispositioned as waste or recycled material.</p> <p>The structure would be demolished using a tracked excavator equipped with hydraulic attachments (shear/crusher, clamshell, etc.), working south to north across the floor slab. The first floor would be removed to the north edge of the structure, although some of the structural members may remain to stabilize the building and retaining walls remaining after demolition, depending on the results of a structural analysis.</p> <p>The anticipated duration of the mechanical demolition is four to six months.</p>		<p>The initial objective during demolition would be to remove structures and appurtenances connected and adjacent to the primary Building 881 structure to allow unrestricted access to that structure. Additionally, the filter plenum and supplied air units would be removed from the roof of the building. Removal of these features exposes the main structure and allows access to the elevated portions of Building 881.</p> <p>In order to prepare the facility for demolition, all non-loading bearing walls will be removed. Once the equipment and non-loading bearing walls have been removed, and necessary decontamination has been completed, the preparation for demolition will be initiated. It is anticipated that this preparation will be conducted after preliminary pre-demolition surveys have been completed by the building RCTs but before the final pre-demolition surveys is conducted. The preparation will consist of roof and exterior wall drilling and interior column drilling and load bearing walls modifications. Floor severance will also be required, but it is anticipated that this will be one of final activities prior to initiating demolition.</p> <p>Production loading will commence on the 1st floor of the structure, then move vertically to the top areas of the building. Necessary signage will be posted prior to the commencement of loading operations. Charges will be assembled and placed into holes drilled in reinforced concrete columns and walls.</p> <p>The drilling and preparation could be completed in 30 days concurrent with other decommissioning activities, loading operation will take 5 days, and the actual demolition could be completed in 1 day.</p>

¹ Each area evaluated, has a narrative row followed by an evaluation of the criteria: + is a positive aspect, 0 is a neutral aspect, and - is a negative impact, indicating the ranking of hazards, impacts, or acceptability

² The project descriptions are based on proposed demolition processes; the actual processes may differ slightly and will be documented in the Demolition Plan

Health and Safety	Mechanical Demolition	Explosive Demolition
<p>Qualitative assessment of this demolition method is considered to have an average overall medium/high risk to Site workers, personnel, equipment, and property if hazards are not properly mitigated. However, when proper engineering, administrative, and Personal Protective Equipment (PPE) controls are implemented, the average overall risk is considered to be low. Major potential hazards/sources identified for the major operations include the following:</p> <ul style="list-style-type: none"> • Contact w/electrical • Struck by moving vehicles • Caught between/pinch points • Contact with sharp objects • Contact with petroleum product (hydraulic fluid) • Overexertion from material handling • Struck by (debris, re-bar) • Exposure to dust (concrete) • Exposure to noise (breaker) • Equipment accident (heavy equipment) <p>Major controls include the following:</p> <ul style="list-style-type: none"> • Work control document • Job Hazard Analysis • Pre-evolution Briefings & Awareness • Use of trained and qualified personnel • De-energizing electrical power • Establish exclusion zones • High visibility vests • PPE • Dust suppression 	<p>Qualitative assessment of this demolition method is considered to have an average overall medium/high risk to Site workers, personnel, equipment, and property if hazards are not properly mitigated. However, when proper engineering, administrative, and PPE controls are implemented, the average overall risk is considered to be low. Major potential hazards/sources identified for the major operations include the following:</p> <ul style="list-style-type: none"> • Fall from elevation (roof) • Contact w/electrical (drill) • Contact w/ sharp objects (drill bit) • Struck by debris (concrete) • Falling debris below (concrete) • Exposure to dust (drill, explosion) • Exposure to noise (drill, explosion) • Overexertion from material handling (equipment) • Unplanned detonation (explosives) • Unplanned structural collapse (walls) • Fall on same level (debris, re-bar) <p>Major controls include the following:</p> <ul style="list-style-type: none"> • Work control document • Job Hazard Analysis • Pre-evolution Briefings & Awareness • Use of trained and qualified personnel • De-energizing electrical power • Establish exclusion zones • High visibility vests • PPE • Dust suppression 	<p>Overall Risk to Site Workers, personnel, equipment, and property</p> <p style="text-align: center;">-3</p>
		<p style="text-align: center;">+4</p>

³ Overall, the use of an "Excavator with Attachments" will take a significantly longer period time and require workers to be in closer proximity to the demolition. Because of this and the fact that method's average overall mitigated risk rating was low, this method was given a negative (-) aspect rating.

⁴ It is estimated that use of this method would save approximately 4-6 months off the project schedule and, in turn, further mitigates potential risk exposures to Site workers, personnel, equipment, and property. Based on this, this method was given a positive (+) aspect rating.

Environmental	Mechanical Demolition	Explosive Demolition
	<p>This method has medium environmental impacts:</p> <ul style="list-style-type: none"> Impacts to air quality: an operator wetting the structure with a fire hose will control fugitive dust. This will result in more dust generation during the lengthy demolition process. Vehicle and equipment emissions will be higher with this method due to the duration. Impacts to surface water quality may occur, such as runoff generated during and after dust control. Some impacts to soils are expected from dust control, the falling structure and vehicular traffic. No soil contamination is expected, as the facility will meet the unrestricted release criteria prior to demolition. No impacts to wildlife are expected. Efforts will be taken to cordon off the area to wildlife. This method may generate additional incidental waste (i.e., trash) during demolition due to the duration. It is expected to take four to six months. Resource use is increased by this method due to the demolition duration. 	<p>This method has minimal environmental impacts.</p> <ul style="list-style-type: none"> Impacts to air quality: fugitive dust will be controlled by a filter system during drilling and a street sweeper and hoses after demolition. Vehicle and equipment emissions are less with this method due to the one-day duration. Impacts to surface water quality may occur, such as runoff generated during and after dust control. Minimal impacts to soils are expected from the falling structure. No soil contamination or erosion impacts are expected, as the facility will meet the unrestricted release criteria prior to demolition. No impacts to wildlife are expected since the building is in the industrial area. However, efforts will be taken to cordon off the area to personnel and wildlife. This method will generate little additional waste (chain link or geotextile containment only) when compared to the mechanical methods. Resource use is minimized by this method, as the demolition duration is limited to one day.
Soils and Geology	-	+
Air Quality	-	0
Water Quality	-	0
Human Health and Safety	-	0
Ecological Resources	0	+
Historical Resources	0	0
Visual Resources	0	0
Noise	-	0
Structural	This method is technically feasible. Of the two methods evaluated, this is the most labor intensive and purely mechanical machinery brute force.	+
		This method is technically feasible. The mechanical portion of this method consists of drilling and wall removal. The explosives do nearly all the work. Upon placement and detonation of the explosives, the structure would be 100% on the ground and sized to manageable chunks.

Technique is efficient, safe and responsible	Mechanical Demolition	Explosive Demolition
Economic	The cost range for mechanically demolishing Building 881 is \$1,961,280 to \$2,451,600.	The cost for explosive demolition of Building 881 is \$932,000.
Cost	-	+

Attachment II
Building 881 Demolition Strategy

DOES NOT CONTAIN
OFFICIAL USE ONLY INFORMATION

J. A. Mackinnon
Name/Org. *EMCBO* *Class in* Date *10/6/05*
OK for public release

1. Building 881 Demolition Strategy

This strategy is a narrative to support the RSOP notification for Facility Disposition and Concrete Recycling for the 881 Project and addresses the demolition preparation, demolition, and backfill of the area to the Final Land Configuration. This strategy also indicates how the requirements of the RSOP for Recycling Concrete will be met. In general, the building will be dispositioned as follows:

- In-process surveys will be conducted, and the area will be designated a plutonium or uranium area.
- Components will be removed and areas decontaminated, as necessary.
- The area will be prepared for demolition (expose rebar, drilling, and wall removal), as necessary.
- Final surveys will be performed.
- Areas will be backfilled as necessary to minimize voids.
- The floor severance and column rebar will be cut
- The building will be demolished using explosives.
- The demolished material will be proof-rolled.
- A choking layer of gravel will be placed on the demolished debris.
- Recycled concrete will be placed to within 3 feet of the final grade.
- Soil will be placed on the last 3 feet of the final grade and reseeded.

1.1 Building History

Building 881 is a rectangular, concrete multi-story structure encompassing approximately 245,160 square feet. It has 17,870 square feet in the basement, 86,300 square feet on the first floor, 6,000 square feet on the first floor mezzanine, 121,460 square feet on the second floor, and 13,530 square feet on the second floor mezzanine. Additionally, there are two rooftop structures, supply and exhaust filter plenums, 3,600 and 9,470 square feet, respectively. Four additions have been built since the original construction in 1952:

- 1956, a two story Annex, 31,600 square feet including supply and exhaust ventilation and a stack added to the northwest corner to provide additional machining capability. Additionally, several radiography vaults were added in the northeast corner of the structure
- 1969, the pressure test facility was added on the east side
- 1986, the new two-stage, HEPA exhaust filter building was built on the roof of the existing structure, and an exhaust chase was added to the east side to bypass the original single-stage exhaust filters

Associated facilities within the 881 Complex addressed by this strategy include:

- Building 887, Sewage and Process Waste Lift Station is located south and down-gradient of the Building 881, and was a part of the original 881 Complex construction in 1952. The reinforced concrete structure has a large below-grade vault containing 7 process waste collection tanks, and was approximately doubled to its current size of 1,555 square feet in 1955.
- The 881 Tunnel is an underground reinforced concrete passageway to Building 883 that was added as part of the Annex construction in 1956.

Building 881 was designed to house all Site enriched uranium weapons operations. Original operations included the uranium oxidation, fluorination, reduction, casting, machining, and pit

assembly. Support operations included waste recovery, analytical and standards laboratories, radiography, stainless-steel component and maintenance machining, and laundry.

In the 1970s and 1980s, Building 881 was reconfigured from a production facility into a building housing Site support operations as the demand for uranium components declined. All uranium operations and most of the laboratories were stripped out in 1967, and new laboratories, the central computer facility, and a number of offices and research and development activities were added. Stainless steel component machining was finally relocated to Building 460 in 1985.

1.2 Building Structure

Building 881 is a large multi-story building constructed of cast concrete walls, columns, and ceilings erected on spread footings with reinforced concrete beams. The main foundations of the building are individual spread footings of concrete for the interior columns and continuous footings of concrete for the exterior walls. The spread footings have a maximum size of 11-feet-square by 2-1/2-feet-thick, and the minimum size of 4-feet-square by 1-foot thick. The structure is reinforced concrete columns and cast concrete walls and floors. The continuous footings vary from 10- to 16-inches thick. The building contains a partial basement consisting of internal tunnels. The building is partially built into the hillside, with the roof being approximately the same elevation as the grade of the northwest corner. The structure is designed to withstand forces considerably above normal static loading based on defense mission design requirements.

The north and west walls of the building are built into the hillside descending to three feet below the floor level at the south dock. There are two loading docks on the east side, also built into the hillside and a number of retaining walls. The roof is covered with rigid insulation material and membrane roofing.

1.3 Regulatory Approach

The type II facilities (Buildings 881, 881F, and 887) will be demolished and backfilled in accordance with the RSOPs for Facility Disposition and Concrete Recycling. The characterization and final survey will be conducted in accordance with the B881 project-specific In-Process Radiological Characterization Plan and the Site-Wide Pre-Demolition Survey Plan.

The backfill specification is consistent with the RSOP with two exceptions. The RSOP indicates that in general, the resulting backfill will contain fragments ranging in size from 6 inches to less than 0.1 inches. The RSOP allows some flexibility, and the backfill specification has been written to allow concrete up to 12 inches in size with some larger fragments if special placement methods are used.

The RSOP also indicates that backfill placement and compaction methods will result in a soil compaction of 80% +/- 10% and that the backfill will be geotechnically tested prior to and during backfill operations. Determination of the relative compaction (percent compaction) of soil is performed in three steps:

1. The maximum dry density achievable on a sample of the soil is determined in a laboratory setting using predefined procedures, such as ASTM D 698 ("Standard" Proctor density) or ASTM D 1557 ("Modified" Proctor density).
2. The dry density of the fill as placed in the fill is determined using a standard field test such as ASTM D 2922 (nuclear method) or ASTM D 1556 (sand-cone method).
3. The field dry density is divided by the laboratory maximum dry density. The result is the relative compaction (percent compaction).

These methods have been developed for compaction measurement for fine- to medium-grained natural soils (clay, silt, sand, and gravel) with sufficient plastic fines to provide at least a small degree of cohesion. The laboratory methods (D 698 and D 1557) are specifically limited to materials with 30% or less (by weight) retained on the 3/4-inch sieve. Since the concrete debris contains particles up to a foot in size, a laboratory maximum dry density cannot be determined. Therefore, a relative compaction cannot be determined.

On the other hand, except for highly plastic clays (where large clods and clay balls form large voids), it is difficult to obtain relative compaction of less than 80% of standard proctor density, even with material simply dumped from a truck or scraper. This is especially true for granular materials without plastic fines.

Granular fill is commonly used for utility trenches and pipelines, where mechanical compaction is difficult but firm support (i.e., limited settlement) is desired, because it is relatively dense when initially dumped into place. Vibratory compaction can be applied to further densify the material if desired. Method specifications using vibratory rollers are commonly used for compaction of granular materials such as rock fill dams where settlement needs to be limited.

Because the sources of fill anticipated for use during backfilling at Buildings 881 will be comprised of unclassified granular soils layered with recycled concrete material, obtaining meaningful and reproducible measurements of relative compaction is impractical. Taking into consideration that the future land use for these areas is undeveloped open space, a method specification that defines the standard placement procedures is more suited to provide a relatively uniform fill free of detrimental voids. As a result, a method specification is appropriate with this kind of backfill material, and a method specification will be utilized to ensure compaction.

2. In-Process and Pre-Demolition Survey

Since Building 881 has had both plutonium and uranium processing within the building in the past, a project-specific In-process Radiological Characterization Plan was prepared. To direct the decontamination activities, it is necessary to know which areas have transuranic contamination and which areas have only uranium contamination. Since some areas are known to have transuranic contamination above the 100 dpm/100 cm² action limit, a sampling approach was developed to identify the extent of the transuranic contamination. This approach uses knowledge of the building history along with previously collected samples to characterize survey units as transuranic or uranium only.

The building history was discussed with site employees that were aware of the processes performed in the building. Maps were generated that displayed the areas of transuranic processing at any time in the building's history. Process piping and ventilation were mapped to determine if they would also cause further transuranic contamination in other areas of the building. Survey units within the areas of highest potential for transuranic contamination were sampled in a biased manner so that the most likely contaminated locations were selected. Survey units with sample results above 100 dpm/100 cm² are classified as transuranic contaminated for decontamination purposes.

When the in-process survey process is complete, a map will be generated annotating areas throughout the building as uranium or plutonium contaminated. This map will be used for decontamination and pre-demolition surveys.

3. Preparation for Demolition

In order to prepare the facility for demolition, all non-load bearing walls will be removed. Once the equipment and non-load bearing walls have been removed, and necessary decontamination

14

has been completed, the preparation for demolition will be initiated. It is anticipated that this preparation will be conducted after preliminary pre-demolition surveys have been completed by the building RCTs but before the final pre-demolition surveys is conducted. The preparation will consist of roof and exterior wall drilling and interior column drilling and load bearing walls modifications. Floor and column rebar severance and stair modifications will also be required, but it is anticipated that this will be one of final activities prior to initiating demolition.

The preparation of the building will be conducted under several work control documents. The structural modifications will be conducted by the explosive demolition contractor under a work control document that includes a work plan, engineering analysis, job hazard analysis, pre-evolution briefings, and matrix of the areas to be modified. The contractor will not initiate any modification until the Demolition or Project Manager has signed off on the area. The Demolition/Project Manager signature will signify concurrence that the proposed modification is consistent with the requirements in the engineering analysis and that the final/preliminary surveys are complete. The backfilling prior to demolition will be conducted by Kaiser-Hill under separate work control documents.

3.1 Roof and Exterior Walls

Vertical holes will be drilled in exterior walls for subsequent explosives placement. Holes will be drilled on approximate 3 foot horizontal centers and will be drilled in the exterior walls of the building. Holes will be sub-drilled 2- to 3-feet beyond the desired removal limit.

All holes in the roof shall be drilled with a TR300 self-contained hydraulic track drill with a weight of approximately 10,000 pounds. The roof of the structure has been calculated to have the capability of adequately supporting the weight of this drill.

3.2 Drilling of Interior Columns and Load Bearing Wall Modifications

All columns and modified load bearing, reinforced concrete walls existing on the 2nd floor Mezzanine, 2nd floor, 1st floor Mezzanine and 1st floor shall be drilled with horizontal 1 3/4-inch to 2-inch diameter holes for subsequent explosives placement. The number of holes per element will depend on the column dimension. Holes shall be drilled with handheld pneumatic jackleg drills or the TR300 self-contained hydraulic track drill. Floor loading capacities have been calculated to be sufficient to support the weight of such equipment.

In certain areas around vaults and hallway walls, there exist continuous poured reinforced concrete walls. Prior to drilling operations, these walls will be modified by arching them with pneumatic or hydraulic hammers to create columns for subsequent drilling. Pre-removal and modification of aforementioned walls have been analyzed by a registered professional engineer, and will not adversely effect the structural integrity of the building.

4. Backfill Prior to Demolition

Several rooms/areas will be backfilled prior to initiating final demolition activities. Many of the areas will be backfilled to minimize large voids. Backfill will consist of any combination of sand, pea gravel, flowable fill and/or recycled concrete. At a minimum, the following areas will be backfilled prior to demolition activities:

- The basement, management units M and F, which will require approximately 7,750 cubic yards of fill material
- The vaults (Rooms 247, 248, 248A, 249, and 249A), which will require approximately 1,800 cubic yards of fill material

- The electrical pit (Room 286), which will require approximately 360 cubic yards of fill material
- The concrete stack (S1) base, which will require approximately 500 cubic yards of fill material
- The entrance to the 883-881 concrete tunnel at the 883 interface, which will require approximately 31 cubic yards of fill material
- The elevator shafts, which will require approximately 61 cubic yards of fill material
- The building drainage system/sumps, which will require approximately 20 cubic yards of fill material
- B887 waste transfer station, which will require approximately 970 cubic yards of fill material

These backfill activities are being conducted prior to demolition because the demolition method will not fill these areas adequately and/or there is the potential to result in an unacceptable amount of surface subsidence.

An engineering analysis was conducted on several of the areas to determine whether these areas could be left with no fill. The engineering analysis contained several very conservative assumptions and is considered a worst-case evaluation. The areas evaluated include:

- Boiler tunnel and stack foundation (located basement southeast corner column L-1), which can support the final soil overburden without reinforcement and would continue to exist without collapse for 1,000 to 2,000 years.
- First floor exhaust stack tunnel and stack foundation (located at the north side column J-20 to H-20), which can not support the final soil overburden without reinforcement and could continue to exist without collapse for approximately 500 to 1,000 years.
- Second floor exhaust stack tunnel and stack foundation (located at the northeast column K-18), which can support the final soil overburden without reinforcement and could continue to exist without collapse for approximately 1,000 to 2,000 years.
- Second floor vaults (located northeast column M-17), which can not support the final soil overburden without reinforcement and could continue to exist without collapse for approximately 500 to 1,000 years.
- Second floor tunnel from B881 to B883 (located at column A-20), that can support the final soil overburden without reinforcement could continue to exist without collapse for approximately 1,000 to 2,000 years.

Although the first floor exhaust stack tunnel and stack foundation cannot support the soil overburden, the depth of the tunnel/stack foundation are such that it is unlikely that there would be any depression at the surface after collapse. However, in order to backfill over the remaining stack and revegetate the area, some fill needs to be placed in the stack foundation. Fill will be placed in the stack with an excavator. The excavator will alternate buckets of processed concrete with buckets of soil or pea gravel. Water will be used throughout the activity to control dust and facilitate placement. When the fill is within 3 feet of the final grade, the soil around the stack will be excavated; the stack foundation will be removed within 3 feet of final grade; and the area backfilled with soil. All of the stack foundations will be filled using the same method.

The vaults and basement will be backfilled with recycled concrete, soil, and/or flowable fill. Initially, a bobcat and/or a conveyor system will be used from within the building to place processed concrete and cinderblock walls within the vault area. When the bobcat and/or a conveyor system has completed all of the fill that can safely be placed, the soil above the vaults will be excavated and several holes will be punched into the ceiling with an excavator with a hoe

ram. Flowable fill will be pumped into these holes until the area has been filled. The soil will be replaced over the vault areas.

The boiler, second floor exhaust, and 881-883 tunnels will be left without backfilling. It is anticipated that as fill is placed adjacent to these areas, some fill will fall into the opening until a wedge is present inside the tunnel, and there will be a solid fill at the interface of the tunnel and the building.

4.1 Filling of the Building 881-883 Tunnel

The tunnel systems north (to Building 883) will remain in place. The tunnel will be decontaminated to unrestricted release levels and flowable backfill-soil/Portland cement mix suitable of achieving compressive strength of approximately 50 psi will be used to create a plug on the 883 side of the tunnel.

The tunnel area will be blocked off into sections, at the doorway, resulting in an individual area that can be filled completely to the ceiling. Blocking materials may be current doors, properly reinforced, if necessary. The intent is to eliminate the potential to enter the 881-883 tunnel and go toward the backfilled area of Building 881. With the tunnel area effectively sectioned and penetration locations identified, the concrete roof of the tunnel will be exposed by removing overlying soil at the location and punch a hole through the exposed concrete roof. Flowable fill material would then be pumped/placed through the holes, alternating placement locations to keep a uniform lift of material. Once the tunnel section is full, the soil removed to expose the tunnel roof would be replaced.

The other areas to be filled within the building will use a combination of the methods described depending on the location to be backfilled and the size of the area.

5. Stainless Steel Floors and Other Miscellaneous Remnants

Insignificant quantities of metals and other material will be left in Building 881 during the demolition and be included in the demolition backfill. Materials include the following:

- Stainless steel floors, where the stainless steel and concrete underneath the stainless steel has been shown to meet the unrestricted release criteria
- Reinforcing steel in the concrete that is demolished in Building 881
- Embedded metal pans in ceiling/floors that are part of original construction
- Metal edges resulting for component removal activities
- The metal roof over the northwest portion of the 881 annex
- Built-up roofing material
- Minor amounts of non-friable asbestos mastic remaining on loading-bearing walls and ceiling after asbestos removal

Stainless steel floors were installed in the original construction of Building 881. The current decommissioning plan proposes to leave the floors in place during demolition. The floors would become part of the demolition debris. The stainless steel material will remain approximately 20 to 30 feet below final grade.

The floor material is a type 304 austenitic stainless steel, alloyed with chromium (~18 wt.%) and nickel (~8 wt.%).¹ This alloy promotes a stable chromium oxide surface layer that protects the base material and exhibits excellent corrosion resistance in industrial and rural atmospheres, similar to conditions that would be expected following demolition. Conditions for corrosion (i.e.,

¹ Steel Products Manual; Stainless and Heat Resisting Steels, Pp. 18-20, American Iron and Steel Institute, 1000 16th Street, N.W., Washington, D.C. 20036, December, 1974.

dissolution) include exposure to aqueous solutions containing significant levels of chlorides, exposure to organic films, or galvanic coupling to another metal. Mechanisms for corrosion do not exist in this application and service corrosion data suggests that the floors would be effectively inert with no impact to the environment for an indefinite period.^{2 3}

The overall quantity of stainless steel and other remnants of decommissioning activities are de minimis when compared with the entire backfilled area. The total quantity of backfill estimated for Building 881 to achieve Final Land Configuration requirements is 108,000 cubic yards of material, and the following is an estimate of the anticipated backfill constituents:

- Soil, 72%
- Choking layer/granular fill, 11%
- Concrete demolished and backfilled in place, 9%
- Concrete (recycled) processed and placed with equipment, 4.6%
- Other steel including reinforcing steel in the concrete demolished and backfilled in place and resulting from embedded items and remnants from component removal, 2%
- Built-up roofing material, 0.008%
- Stainless steel, 0.006%
- Metal Roof, 0.002%
- Mastic, 0.0009%

There is a section of steel roof on the northwest portion of Building 881 that was added during a renovation. Removal of the roof presents several issues. First, the demolition contractor has requested that the roof be left in place in order to help with dust control during demolition. Second, security has requested that the roof be left in place during demolition to assist in control and access to the building. From a safety standpoint, the removal of the roof prior to demolition and after demolition has significant issues. Removal of the roof prior to demolition is prohibitive from a practical standpoint because the roof cannot be accessed with heavy equipment from the edge of the building due to its size and weight. In order to remove the roof, it would have to be segmented manually and rigged off, which presents numerous safety risks to the workers.

If the roof were left in place during demolition, removal would mean tracking heavy equipment into the pile and dragging the roof segments to the southern opening of the building. After demolition, the metal roof will be at least 20 to 30 feet below the existing ground surface and there is approximately 400 feet to the southern opening at the further most point. Removing the roof this way would be time consuming and difficult because the rubble will be difficult to maneuver over and the pieces will have to be sized to allow removal. In addition, the portions of the walls that are harmonically delaminated will have to be pushed into the void created by the demolished building, which would require that the metal roof be dug out for access.

Since there are numerous positive reasons to leave the roof in place during demolition and several issues with removing the roof after demolition, it is proposed that the metal roof be backfilled with the building rubble. The overall quantity of metal left in the backfill by the roof is minimal and will not have a negative impact.

On Building 881, there is built up roofing material consisting of asphalt, gravel, vermiculite and rubber. This layer ranges from 6 to 10 inches across the top of Building 881; the difference in thickness is probably due to repairs throughout the building history. It is proposed that the asbestos flashing will be removed from the roof, but the remaining material will not. This is a

² Corrosion and Corrosion Control, Herbert H. Uhlig, R. Winston Revie, Third Edition, John Wiley and Sons, 1985

³ Metals Handbook, Volume 3, Properties and Selection: Stainless Steels, Tool Materials, and Special Purpose Metals, Ninth Edition, American Society for Metals, 1980

very minor amount of material that will not impact the backfill, and the removal of this material will cause leaks and standing water throughout the building.

The Building 881 Close-out Report will contain drawings and/or floorplans of Building 881 and the location of the areas backfilled prior to demolition and the locations of the stainless steel floors and other building remnants.

6. Demolition

Initial demolition activities will involve stripping remnant equipment, supplied air units, and other miscellaneous materials from rooftops that were not removed earlier during decontamination. As part of demolition site preparation, existing features associated with Site utility systems will be located, marked, and evaluated for isolation purposes.

Protective barriers or fences will be erected around permanent Site features designated to remain during demolition. As necessary, run-on and run-off control features will be implemented; temporary diversion berms, erosion control silt fencing and interceptor ditches will be installed; and existing drainage culverts and ditches will be cleaned out as required to divert significant overland flow away from the demolition site.

Traffic patterns and specific loading areas for waste management will be established, as will temporary stockpile areas for debris. Work control during demolition will consist of the Contractor's Work Plan, a job hazard analysis, a justification for continued operation, a special security plan, and a Standing Order. The Standing Order will combine the requirements from all of the documents and a checklist will be developed to identify work process and hold points through explosives delivery, loading and detonation.

6.1 Floor Severance

Following all other preparation activities in the building, reinforced concrete floor slabs will be severed from exterior walls. Floor severance will be made with hydraulic hammers mounted on skid steer loaders. Following the floor severance (which will be approximately 4-inches wide), selected reinforcing rod in floors and beams will be pre-cut with oxygen acetylene torches. Floor loading, reinforced concrete cutting and rebar severance has been analyzed by a registered professional engineer.

6.2 Test Shot

Loading and demolition will be conducted over a five (5) day period. On the first day of explosive delivery, prior to production loading, a test blast will be conducted on certain interior elements of the structure to determine the optimum loading densities for production blasting. The exact location of test blasting shall be determined and an Engineering Survey will be conducted to confirm that any test blasting will not adversely effect the structural integrity of the building.

6.3 Loading and Demolition

Production loading will commence on the 1st floor of the structure, then move vertically to the top areas of the building. Necessary signage will be posted prior to the commencement of loading operations. Charges will be assembled and placed into holes drilled in reinforced concrete columns and walls.

All explosives will be handled and placed by trained professionals. Where holes are located in elevated positions, loading will be performed from a man lift or scissor lift. On the final day prior to the implosion, the exterior walls of the structure, which are accessed from the roof, shall be loaded.

6.4 Protective Measures During Demolition

The Southern end of Building 881 and other exposed exterior walls will be covered with one or more layers of geotextile fabric, secured so as to prevent premature displacement prior to the detonation sequence.

Should site conditions dictate a need to protect adjacent exposures, protective cover will be placed over sensitive adjacent elements using either hard (plywood) cover or drape (fabric) cover depending on need.

6.5 Demolition of Outbuildings

Building 887 (Sewage and Process Waste Lift Station) housed seven tanks that collect Building 881 process waste prior to it being pumped to Building 374 through the process waste system, and pumps building sanitary waste to the Sewage Treatment Plant. It was constructed of cast-in-place reinforced concrete walls and slab roof, with cast concrete pads to support tanks and equipment. The building layout consists of tank and pump vaults 10-15 feet below grade with an access house aboveground on the north end.

The building will have all systems and equipment removed, and the concrete will be shaved and rinsed. If the clean closure standards are met, the demolition approach consists of using a tracked excavator with a shear/crusher attachment to expose the building and vault interior, remove any residual items, and reduce to rubble the access house, vault roof, and walls to a depth of greater than three feet below grade. The recycle and waste materials will be segregated and dispositioned, and the concrete rubble will be staged for use as backfill material. The vault area will be backfilled with appropriate materials to the final grade.

7. Backfill After Demolition

After the demolition, the resulting depression will be backfilled. The material in the building area will not be removed after demolition, which is why such care will be taken during the demolition preparation to minimize voids and the potential for material to hang-up after demolition. If walls or floors hang-up after demolition, then heavy equipment will be used to flatten the wall and/or floors, and the fill will be proof-rolled according to the engineering specification prepared for Building 881 backfill. The proof-rolling activity will be used to evaluate the success of the demolition on flattening the demolished fill in place. The evaluation will be visual, and walls that have fallen vertically will have to be demolished into a relatively flat pile. Following the proof-rolling, a choking layer of gravel will be placed, followed by recycled concrete and soil.

In accordance with the RSOP for Recycling Concrete, placement requirements for recycled concrete were established based on the design requirements for the backfill. The goal of the backfill operations will be to create a stable area, consistent with a Wildlife Refuge, with minimal long-term maintenance. Based on this goal and the requirements in the RSOP, a backfill specification was prepared by a Colorado registered professional engineer. One exception and one clarification of the RSOP requirements were made in this project-specific backfill specification and are outlined in Section 1.3.

8. Building 881 Groundwater Modeling

8.1 Building 881 Model Area – Model Details

Basement slabs and walls associated with Buildings 883 and 881 were included in the Building 881 area model. Figure 1 shows the integrated flow model area, numerical grid, and boundary cells aligned with Woman Creek to the south. Boundary cells were defined far enough away from the 881 and 883 buildings to prevent impacts to these areas. This is reasonable given that groundwater levels within the IA typically respond mostly to direct recharge and evapotranspiration (KH, 2002) than lateral inflow conditions (i.e., constant head cells along boundary).

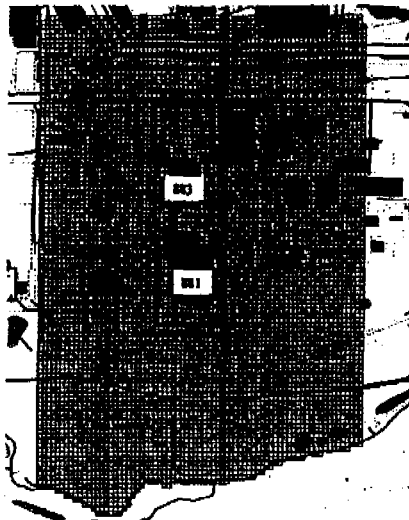


Figure 1 Model Boundary and Buildings of Interest – Building 881 Model Area

Engineering drawings of subsurface basement walls and slabs for Buildings 881 and 883 reviewed combined with the demolition techniques and final land configuration. Based on the regrade topography provided, the entire Building 881 slab remains intact, while portions of the basement walls to the south are removed to within 3 feet below the new topographic surface. Although Building 883 doesn't extend as deep below grade as Building 881, most of its subsurface basement slab and portions of walls remain.

Weathered bedrock surface and surface regrade topography dominate groundwater flow paths within the model area. Under current conditions, groundwater south of 881 flows southward toward Woman Creek because the hillslope south starts here, while north of Building 881 groundwater flows in a more easterly direction, consistent with the topographic and bedrock surface gradient directions.

Hydrologic conditions for two demolition scenarios were evaluated using the integrated flow model for the Building 881 area. The first scenario assumed that all vertical walls for Building 881 were impermeable, while the second scenario assumed that the north and south walls were permeable. There were two reasons for simulating these scenarios. The first was to evaluate whether groundwater levels within and surrounding the 881 Building would be reduced significantly by using permeable walls. The other reason was to evaluate whether impermeable walls reduce potential southern migration of a VOC plume immediately to the west of Building 883.

8.2 Building 881 Model Area -- Demolition Simulation Results

Simulated mean and minimum annual groundwater depths below the proposed regrade topography for the wet year climate sequences for the impermeable wall scenario are shown on Figure 2. Selected grid cells denote areas predicted by the model where groundwater depths are less than 1 meter below grade. The simulated depths are calculated for a single 100-year basis annual wet climate sequence following two typical climate years (WY2000) to stabilize initial saturated and unsaturated zone flow conditions.

Results indicate that simulated closure groundwater depths surrounding Building 881 are well below 1 meter for both cases, but more so for the case using permeable walls. This reduces the potential for slumping and possible exposure of the structure, particularly along the hillslope to the south. In both cases, groundwater depths decrease towards the north and eastern model areas because of thinning unconsolidated material thickness. Simulated groundwater depths also decrease to less than 1 meter towards Woman Creek in response to the hillslope structure and thinning unconsolidated materials near the creek. Depths do not buildup within and above the 881 slab because its depth below the regrade topography is more than several meters.

Although groundwater depths decrease upgradient and within Building 881 compared to the scenario where the walls are permeable, they remain well below a depth of 1 meter below the proposed grade. Groundwater depths immediately north of the remaining Building 883 basement structure are also less than 1 meter, but do not pose a problem with slope stability given the relatively flat regrade topography in this area.

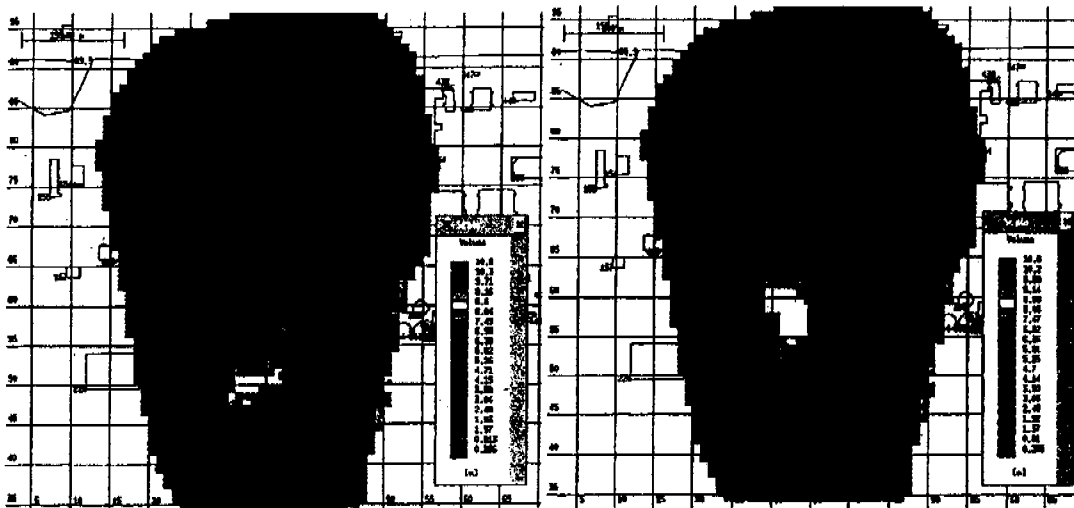


Figure 2. Mean and Minimum Annual Groundwater Depths (m) - Impermeable Wall Scenario

Results of an advective-dispersive transport simulation of a PCE plume signature area located west of Building 883 are shown on Figure 3. Results are shown for the impermeable wall scenario, which is the selected demolition method. It should also be recognized that maximum PCE concentrations are less than currently proposed surface water Preliminary Remediation Goals (PRG).

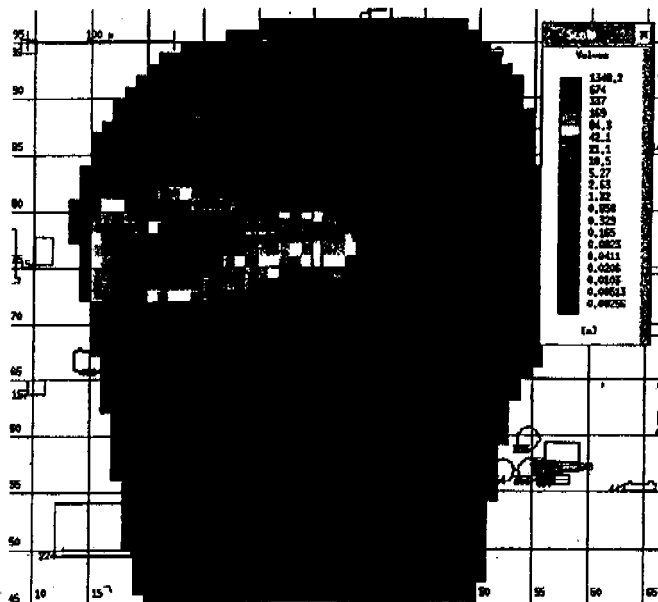


Figure 3. Simulated PCE groundwater distribution after 200 years.

As a result of the Building 881 area modeling, the Building 881 walls and slab will not be made more permeable to prevent southward migration of VOCs west of Building 883. The subsurface structure associated with Building 883 appears to pose no problems with respect to groundwater levels, or transport though, the footing drains between Building 883 and 881 be disrupted to prevent possible pathways for southward migration of PCE intercepted near Building 883.

9. Under Building Contamination Remediation

There was one designated UBC site associated with Building 881 (IHSS 800-2). An under-building investigation was conducted in accordance with the Industrial Area Sampling and Analysis Plan. The Data Summary Report for IHSS Group 800-2 was approved by the LRA on July 16, 2003. Approval of the Data Summary Report constituted regulatory agency concurrence that the IHSS Group is a No Further Accelerated Action required site.

Under building sampling is being conducted under Building 887. Building 887 will not be backfilled until a no further accelerated action is obtained for this area.

Attachments to the notification letter that are referenced or support this strategy:

- B881 Tunnels, Stack Foundations, and Vaults – Structural Analysis for the Prediction of Long-term Condition (Attachment V)
- Building 881 Slope Stability Analysis RFETS (Attachment VI)
- Construction Specification, Section 02220, Fill and Backfill (Attachment VII)
- Construction Specification, Section 02225, Special Backfill (Attachment VIII)
- Evaluation Demolition Methods for Building 881 (Attachment I)

Attachment III
Project-Specific Administrative Record

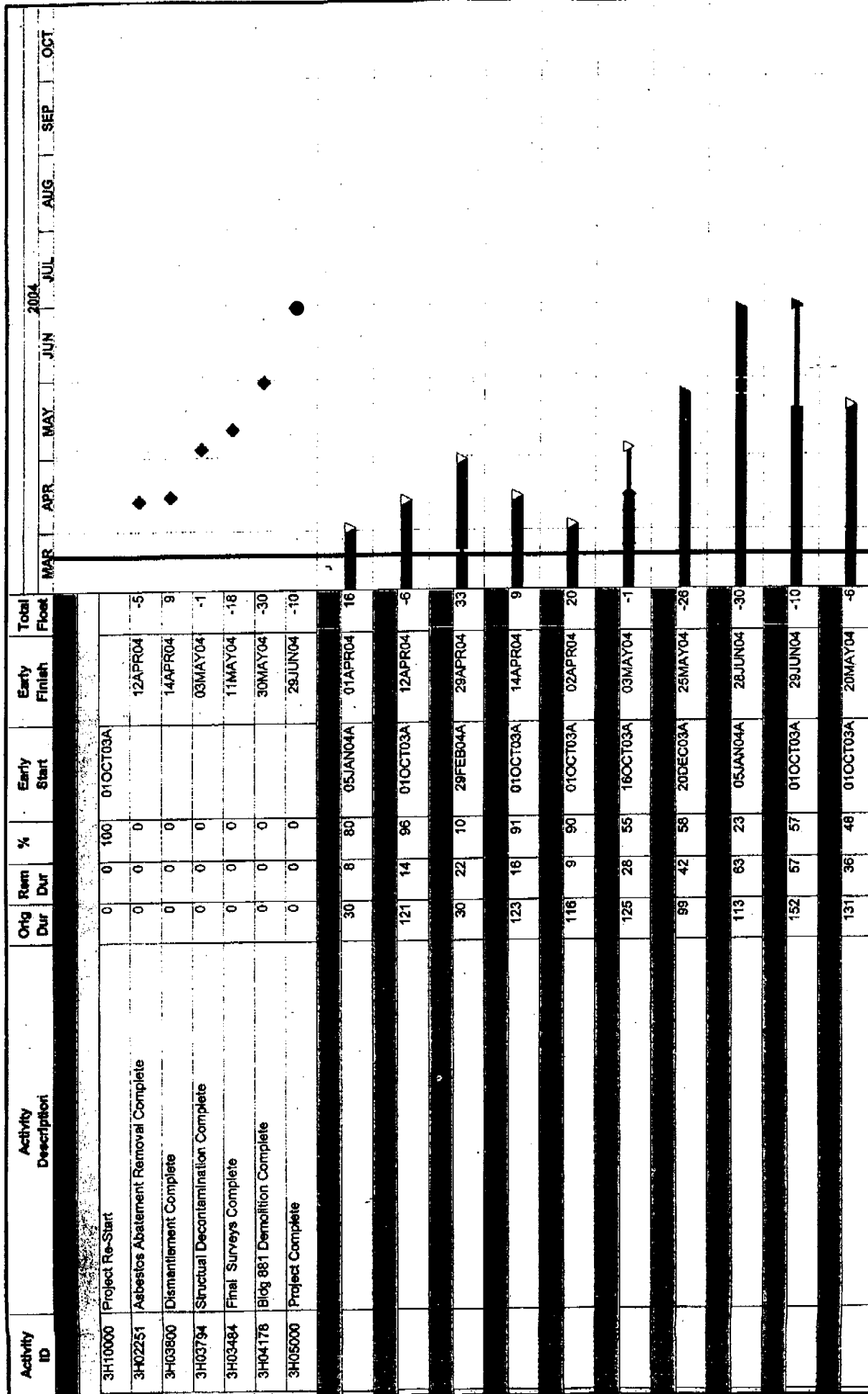
DOES NOT CONTAIN
OFFICIAL USE ONLY INFORMATION

Name/Org *F.A. Nishenko* Date *10/6/08*
EM 60 Class
OK for public release

Building 881 – RSOP for Facility Disposition Administrative Record File

- Final Rocky Flats Cleanup Agreement (RFCA)
- RFETS Decommissioning Program Plan (DPP)
- RFCA Standard Operating Protocol for Facility Disposition
- Pre-Demolition Survey Reports
- Contact Records pertaining to facility disposition
- Notification Letters and subsequent CDPHE correspondence, if appropriate

Attachment IV
Level One Project Schedule



Sheet 1 of 1

ISSA - C881



Start Date
31MAY02
Finish Date
28JUN04
Data Date
22MAR04
Run Date
31MAR04 15:19

KAISER-HILL, LLC
Building 881 Demolition

Issue:



Legend:

Attachment V
B881 Tunnel, Stack Foundations, and Vaults – Structural Analysis
for Prediction of Long-term Condition

CALCULATION/OTHER DOCUMENTS COVER SHEET

CALCULATION NUMBER CALC - 881 - BS - 00050Rev. 0

Section 1: IDENTIFICATION

1. WCF or / Authorization Project Number EED11200	2. Project Title <u>B881 TUNNELS, STACK FOUNDATIONS, AND VAULTS - STRUCTURAL ANALYSIS FOR THE PREDICTION OF LONG-TERM CONDITION</u>	3. Page 1 of 47
3. System Identification (See SX-154, Plant System and Component Identification and Labeling) NA	4. Other (Type of document, e.g., Studies, Conceptual Design Report, Design Criteria, etc.) CAPACITY ANALYSIS	
6. Natural Phenomena Hazard Performance Category (PC) Number <input checked="" type="checkbox"/> PC-0 / NA <input type="checkbox"/> PC-1 <input type="checkbox"/> PC-2 <input type="checkbox"/> PC-3	7. Building Number B881	
8. Engineering Discipline(s) Involved with Calculation: STRUCTURAL		

Section 2: SIGNATURES FOR A CALCULATION

	Discipline	Print Name	Sign	Date
9. Designer(s)	Structural	Keith MacLeod	<i>Keith MacLeod</i>	11/26/03
10. Checker(s)	Structural	Tom Frank	<i>Tom Frank</i>	12/01/03
11. Independent Verifier (for PC-0/NA and PC-1)	Structural	Tom Frank	<i>Tom Frank</i>	12/01/03
12. Peer Reviewer (for PC-2 and PC-3)	NA			
13. Responsible Engineering Manager	PCE	Tim Humiston	<i>Tim Humiston</i>	12/1/03
14. Classification Review	<i>NA</i>	<i>CJFrac120M</i>	<i>Humiston</i>	12/02/03

Section 3: SIGNATURES FOR OTHER DOCUMENTS

	Discipline	Print Name	Sign	Date
15. Preparer				

Section 4: REVISION SUMMARY

16. Description	17. Affected Pages

CALCULATION CONTROL NUMBER: CALC - 881 - NA - 000050 - (REV. 0)

1. IWCP/Authorization Project Number: EED11200
2. Calculation Title:
B881 TUNNELS, STACK FOUNDATIONS AND VAULTS - STRUCTURAL ANALYSIS FOR THE PREDICTION OF LONG-TERM CONDITION

3. The site is considering leaving the concrete portions of tunnels, stack foundations and vaults of B881 in place and not removing them for the final site closure. The tunnels and vaults will remain intact and not be removed or collapsed during the demolition of the building. The stack foundations below the ground will be filled with site material.

The following is the list of the tunnels, stack foundations and vaults that will be analyzed:

1. Boiler tunnel and stack foundation, (located at basement south-east corner L-1).
2. First floor exhaust stack tunnel and stack foundation, (located at north side H-17 to H-20).
3. Second floor exhaust stack tunnel and stack foundation, (located at the north-east K-18).
4. Second floor vaults, (located north-east M-17).
5. Second floor tunnel from B881 to B883, (located at A-20).

This calculation addresses two factors that will be involved with this consideration, which are as follows:

1. What is the projected number of years that the tunnels and vaults will remain standing before it begins to collapse.
2. What will be the depression in the ground surface when the tunnel does collapse.

Therefore, an analysis of the tunnels and vaults structure's present strength and condition is needed to determine what the future long term condition of the tunnels and vaults may be. Based on the results of the analysis a projection can be made as to how many years before the tunnels and vaults will begin to collapse due to natural causes. The analysis is based on the tunnels and vaults loaded only with the soil overburden from the final grade after the completed demolition of the building. The tunnels, stack foundations and vaults will not be subject to any vehicle traffic. The analysis is also based on the groundwater rising to above the tunnels at least part of every year. The tunnels and vaults will therefore be exposed to the corrosive effects of water.

4. Natural Phenomena Hazard Performance Category: NA - it can be reasonably assumed that if an earthquake does occur it will not effect the tunnels, stack foundations and vaults, because they are buried and supported all around by soil.

5. Calculation Objectives (List):

The objective is to calculate the strength of the tunnel without steel rebar reinforcement and just with the strength of the concrete. This will give an indication of whether the tunnels and vaults can support their own weight and soil overburden over a long period of time, once the reinforcement has completely corroded. The natural groundwater flows are expected to rise above the tunnels, stack foundations and vaults at least part of each year. This will expose the tunnels and vaults to water, and over a long enough period of time the reinforcement will

CALCULATION CONTROL NUMBER: CALC - 881 - NA - 000050 - (REV. 0)

corrode. The stack foundations will be filled and supported all around by soil, so therefore they will not collapse.

The objective also is to approximate the effects on the ground surface after the tunnels and vaults have collapsed.

6. List Methods used for Calculation:

Standard engineering design practice and by engineering methods of the (ACI) American Concrete Institute.

7. List Assumptions used:

The assumption that the ground water will rise above the tunnels, stack foundations and vaults for at least part of the year, is based on the report "RFETS Hydraulic Impacts - Building B881 Decommissioning", By Bob Prucha, Kaiser-Hill Water Program Department, (11-25-2003).

8. Identify References:**8.1 Drawings (RFETS drawing no.) & (discipline): (see attached copies)**

Building Layout Drawings: Building B881 - (30881-1,2,3,4, & 5) (Arch.)

Tunnels, Stack foundations and Vaults drawings:

1. Boiler tunnel and stack foundation (located at basement L-1).
Boiler Flue & Stack Substructure - (00S29-0001) (Building)
2. First floor exhaust stack tunnel and stack foundation (located at J-20 to H-20)
Ventilation Stack Foundation & Connection Tunnel - (00S28-0001) (Building)
3. Second floor exhaust stack tunnel and stack foundation. (located at K-18)
Stack Foundation & Tunnel Details - (17507-0002) (Unknown)
4. Second floor vaults. (located north-east M-17)
Radiographic Vault, Rooms 248, 249 and 250 - (00327-0008) (Building)
Plan & Concrete Details Rm. 248, 249 & 250 - 15835-0001) (Building)
Plans, Sections & Details Radiography Room - (20507-0001) (Arch.)
5. Second floor tunnel from B881 to B883. (located at A-20)
Concrete Connection Tunnel Plans & Details - (17530-0002) (Mechanical)

Existing Soil Grades:

Topographic Map Zone E-5 & F-5 - (15510-0037 & 0045) (Site Civil)

Site Closure Final Soil Grades:

Land Configuration Design Basis IA Grading and Drainage Concept -
(51754-C100, C101, & C102) (Civil)

Foundation Drawing with General Notes for Concrete Strength:

Foundation Schedule & Details - (00F02-001F) (Building)

8.2 AISC American Institute of Steel Construction, 9th Edition.

8.3 "RFETS Hydraulic Impacts - Building B881 Decommissioning",
By Bob Prucha, Kaiser-Hill Water Program Department, (11-25-2003).

9. Identify Applicable Design Related AB Documents: NA

The building will be demolition and will no longer exist.

(10/00)

1-V51-COEM-DES-210

CALCULATION CONTROL NUMBER: CALC - 881 - NA - 000050 - (REV. 0)

10. Body of Calculation: Refer to the following calculation pages.

11. Calculation Conclusion:

B881 Tunnels, Stack Foundations and Vaults Structural Analysis for the Prediction of Long Term Condition

Present Strength & Condition of Tunnels, Stack Foundations and Vaults

The tunnels, stack foundations and vaults are in good condition with no cracks or evidence of corrosion. However, after site closure the tunnels, stack foundations and vaults are expected to be exposed, inside and out to ground water, for at least part of each year. The ground water will seep into the concrete and corrode the reinforcement, until at some period of time, the reinforcement becomes ineffective. The final strength of the tunnels, stack foundations and vaults are then dependent on the uncracked ultimate tensile (rupture) strength of the concrete. When the concrete eventually deteriorates and cracks, the roofs will lose all strength and will collapse. The collapse of the roof will cause the soil overburden to fill the tunnels and vaults and cause a depression on the ground surface.

Long Term Durability of Building B881 Tunnels

The long term durability of the tunnels and vaults is first dependent on the period of time that will take to corrode the reinforcement so that it becomes completely ineffective. Once the reinforcement corrodes and becomes totally ineffective, the final collapse of the tunnels and vaults are dependent on the strength of the concrete to support the soil overburden. The calculation analyzed the strength of the concrete of the tunnels and vaults to support the soil overburden once the reinforcement has completely corroded. The stack foundations will be filled with site material and supported all around by soil. Therefore, the stack foundations will not collapse and will continue to exist buried in the ground well after the tunnels and vaults collapse.

Because of the good condition of the tunnels and vaults and the probability that the tunnels and vaults will only be exposed to ground water part of each year, it may take approximately 500 years or longer for the reinforcement to corrode. Once the reinforcement has completely corroded it could take another 500 years or longer for the concrete to deteriorate so that the tunnels and vault roofs will collapse.

The following are the results of the tunnels and vaults concrete analysis to support the soil overburden (Reference sketch in calculations of following pages):

1. Boiler tunnel, (located at basement south-east corner L-1).

The boiler tunnel concrete roof can support the final soil overburden without the reinforcement.

- Therefore, a conservative engineering estimate would be that the tunnels could continue to exist without collapsing for at least 1,000 to 2,000 years.
- The final depression at the surface will be a trapezoidal shaped trench with assumed 45 degree sloped sides and with the following approximate dimensions:

2.0 ft. deep x 27 wide at the surface to 23 ft. wide at the bottom

CALCULATION CONTROL NUMBER: CALC - 881 - NA - 000050 - (REV. 0)

2. First floor exhaust stack tunnel, (located at north side H-17 to H-20).

The first floor exhaust stack tunnel can not support the final soil overburden without the reinforcement. Because the tunnel is deep (16.83 ft.) the soil above the tunnel will arc over the tunnel and support itself long after the tunnel has collapsed. Therefore, there may not be any depression at the surface above the tunnel, long after the collapse of the tunnel.

- Therefore, a conservative engineering estimate would be that the tunnels could continue to exist without collapsing for at least 500 to 1,000 years.
- The final depression at the surface will be a trapezoidal shaped trench with assumed 45 degree sloped sides and with the following approximate dimensions:

4.4 ft. deep x 46 wide at the surface to 37 ft. wide at the bottom

3. Second floor exhaust stack tunnel, (located at the north-east K-18).

The second floor exhaust tunnel concrete roof can support the final soil overburden without the reinforcement.

- Therefore, a conservative engineering estimate would be that the tunnels could continue to exist without collapsing for at least 1,000 to 2,000 years.
- The final depression at the surface will be a trapezoidal shaped trench with assumed 45 degree sloped sides and with the following approximate dimensions:

1.5 ft. deep x 19 wide at the surface to 15 ft. wide at the bottom

4. Second floor vaults, (located north-east M-17).

Second Floor Eastern Pair of Vaults - the concrete roof can not support the final soil overburden without the reinforcement.

- Therefore, a conservative engineering estimate would be that the vaults could continue to exist without collapsing for at least 500 to 1,000 years.
- Because there will only be (3.5') of soil overburden, there will not be enough soil to fill the vaults once they collapse. Therefore, there will be a square trapezoidal shaped depression at the surface extending to the top of each vault, with the sides assumed sloped at 45 degrees. Below the depressions there will be a square hole at each of the unfilled vaults.

Depressions will be approximately = 3.5 ft. deep x 31 ft. x 31 ft. at the surface

Hole at unfilled vaults = 7.4 ft. deep x 24 ft. x 24 ft.

Total depth from surface = 11.0 ft.

CALCULATION CONTROL NUMBER: CALC - 881 - NA - 000050 - (REV. 0)

Second Floor Western Pair of Vaults - the concrete roof can not support the final soil overburden without the reinforcement.

- Therefore, a conservative engineering estimate would be that the tunnels could continue to exist without collapsing for at least 500 to 1,000 years.
- Because there will only be (3.5') of soil overburden, there will not be enough soil to fill the vaults once they collapse. Therefore, there will be a square trapezoidal shaped depression at the surface extending to the top of each vault, with the sides assumed sloped at 45 degrees. Below the depressions there will be a square hole at each of the unfilled vaults.

Depressions will be approximately = 3.5 ft. deep x 23 ft. x 23 ft. at the surface

Hole at unfilled vaults = 6.8 ft. deep x 16 ft. x 16 ft.

Total depth from surface = 10.3 ft.

5. Second floor tunnel from B881 to B883, (located at A-20).

The Second floor tunnel from B881 to B883 concrete roof can support the final soil overburden without the reinforcement.

- Therefore, a conservative engineering estimate would be that the tunnel could continue to exist without collapsing for at least 1,000 to 2,000 years.
- Because there will only be (4.0') of soil overburden, there will not be enough soil to fill the tunnel once it collapse. Therefore, there will be a trapezoidal shaped trench depression at the surface extending to the top of the vaults, with the sides assumed sloped at 45 degrees. Below the depression there will be a trench hole at the unfilled tunnel.

Depression could be approximately = 4.0 ft. deep x 12 ft. wide at the surface

Trench hole at unfilled tunnel = 4.0 ft. deep x 8.0 ft. wide

Total depth from surface = 8.0 ft.

If there are any questions please give me a call.

Keith MacLeod, RFETS Material Stewardship Engineering
B460 C211- 09, phone 303-966-2067, pager 303-212-5674,
fax 303-966-7193, & e-mail keith.macleod@rfets.gov

Calculation Number

CALC-881-B5-000050

Revision Number 0

B881 TUNNELS, STACK FOUNDATIONS, VAULTS STRUCTURAL ANALYSIS.SOIL WEIGHT

DRY WEIGHT = 100 pcf \rightarrow USE SOIL $\gamma = 110$ pcf \leftarrow
 WET WEIGHT = 120 pcf

CONCRETE COMPRESSIVE STRENGTH

(REFER ACI-318-89 pg 329)

WORKING STRESS CONC. COMPRESSIVE STRESS

$$F_c = .45 f'_c \quad \text{or} \quad F_c = 1,100 \text{ psi} \quad f'_c = \frac{1100}{.45} = 2,444 \text{ psi} \leftarrow$$

MOST OF THE DRAWINGS REFER TO PUB. PL (00F02-001F)
 FOR GENERAL NOTES FOR CONC. STRENGTH $f'_c = 3,000 \text{ psi}$

TENSION (RUPTURE) CAPACITY OF CONCRETE

(REF ACI 318-89 9.5.2.3 (9-9) PAGE 91)

$$f_r = 7.5 \sqrt{f'_c}$$

$$f'_c = 3000 \text{ psi} \quad f_r = 7.5 \sqrt{3,000 \text{ psi}} = \underline{410.8 \text{ psi}} \leftarrow$$

RFETS	ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE	Calculation Sheet	Page 0 of 47
Calculation Number	CALC - 881-B5-000050		Revision Number

B881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS.
SOIL OVERBURDEN CALC'S.

① BOILER TUNNEL (AT L-1)

$$\begin{array}{rcl}
 \text{T.O. FLR. ELEV.} & = & 5960'-0'' \\
 \text{TUNNEL HEIGHT} & = & 8'-4'' \\
 & & 5968'-4'' \\
 \text{T.O. FINAL GRADE} & = & 5978'-0'' \\
 & & - 5968'-4'' \\
 \text{SOIL OVERBURDEN} & = & 9'-8''
 \end{array}$$

② FIRST FLOOR EXHAUST TUNNEL (AT H-17 TO H-20)

$$\begin{array}{rcl}
 \text{T.O. FLR. ELEV.} & = & 5968'-0'' \\
 \text{TUNNEL HEIGHT} & = & 16'-2'' \\
 & & 5984'-2'' \\
 \text{T.O. FINAL GRADE} & = & 6001'-0'' \\
 & & - 5984'-2'' \\
 \text{SOIL OVERBURDEN} & = & 16'-10''
 \end{array}$$

③ SECOND FLOOR EXHAUST TUNNEL (AT L-18)

$$\begin{array}{rcl}
 \text{T.O. FLR. EL.} & = & 5988'-4'' \\
 \text{TUNNEL HEIGHT} & = & 6'-0'' \\
 & & 5994'-4'' \\
 \text{T.O. FINAL GRADE} & = & 6001'-0'' \\
 & & - 5994'-4'' \\
 \text{SOIL OVERBURDEN} & = & 6'-8''
 \end{array}$$

④ SECOND FLOOR VAULTS (AT H-17)

$$\begin{array}{rcl}
 \text{T.O. FLR. EL.} & = & 5984'-0'' \\
 \text{TUNNEL HT.} & = & 13'-6'' \\
 & & 5997'-6'' \\
 \text{T.O. FINAL GRADE} & = & 6001'-0'' \\
 & & - 5997'-6'' \\
 \text{SOIL OVERBURDEN} & = & 3'-6''
 \end{array}$$

⑤ SECOND FLOOR TUNNEL FROM B881 TO B883 (AT A-20)

$$\begin{array}{rcl}
 \text{T.O. FLR. EL.} & = & 5984'-0'' \text{ (LOW PT.)} \\
 \text{TUNNEL HT.} & = & 11'-0'' \\
 & & 5995'-0'' \\
 \text{T.O. FINAL GR.} & = & 6002'-0'' \\
 & & - 5995'-0'' \\
 \text{SOIL OVERBURDEN} & = & 7'-0'' \\
 & & 5987'-0'' \text{ (HIGH PT.)} \\
 \text{SOIL OVERBURDEN} & = & 4'-0''
 \end{array}$$

Calculation Number

CALC - 881-BS-000050

Revision Number 0

6881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS1. BOILER TUNNEL (AT L-1)

$$\text{TUNNEL ROOF THICKNESS} = 1'-4" \quad \text{SPAN} = 7'-0"$$

$$\text{LOAD ON ROOF:} \quad \begin{aligned} \text{SOIL WEIGHT} &= 110 \text{pcf} \times 9.67' = 1,064 \text{psf} \\ \text{CONC. WEIGHT} &= 150 \text{pcf} \times 1.33' = 200 \text{psf} \end{aligned}$$

$$1,264 \text{psf}$$

$$\text{TUNNEL ROOF MOMENT: } M_{\text{MAX}} = \frac{WL^2}{10}$$

$$M_{\text{MAX}} = \frac{1,264 \text{psf} (7.0)^2}{10} = 6,194 \text{ft-lb}$$

$$\text{SECTION MODULUS OF ROOF/FY: } S = \frac{12^4 (6)}{6}$$

$$S = \frac{12 (16")^3}{6} = 512 \text{in}^3$$

$$\text{CONCRETE WORKING STRESS} = 1,100 \text{psi (REF. TO DWG'S.)}$$

$$f'_c = \frac{1,100 \text{psi}}{.45} = 2,444 \text{psi}$$

$$f_r = 7.5 \sqrt{f'_c} = 7.5 \sqrt{2,444 \text{psi}} = 371 \text{psi}$$

$$M_{cr} = f_r \times S = 371 \text{psi} \times 512 \text{in}^3 \times \frac{\text{ft}}{12 \text{in.}}$$

$$= 15,829 \text{ft-lb} > M_{\text{MAX}} = 6,194 \text{ft-lb}$$

CONCRETE CAN SUPPORT OVERBURDEN WITHOUT
REINFORCEMENT.

Calculation Number

CALC-881-B5-000050

Revision Number 0

881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS2. FIRST FLOOR EXHAUST TUNNEL (AT J-20 TO H-20)TUNNEL ROOF: THICKNESS = 1'-2" SPAN = 12'-0" $f'_c = 3,000 \text{ psi}$ ROOF LOAD: SOIL WT. = $110 \text{ pcf} \times 16.83' = 1,851 \text{ psf}$ CONC. WT. = $150 \text{ pcf} \times 1.17' = 176 \text{ psf}$ $2,027 \text{ psf}$ TUNNEL ROOF MOMENT: $M_{\text{MAX}} = \frac{2,027(12.0)^2}{10} = 29,189 \text{ #}\cdot\text{ft}$ $f_r = 7.5 \sqrt{3000 \text{ psi}} = 410 \text{ psi}$ $S = \frac{12(14.0'')^2}{6} = 392 \text{ in}^3$ $M_{\text{CR}} = 410 \text{ psi} \times 392 \text{ in}^3 \times \frac{\text{ft}}{12} = 13,398 \text{ #}\cdot\text{ft} < M_{\text{MAX}} = 29,189 \text{ #}\cdot\text{ft}$ TUNNEL CONCRETE ROOF CAN NOT SUPPORT SOIL OVERBURDEN WITHOUT REINFORCEMENT.3. SECOND FLOOR EXHAUST TUNNEL (AT K-18)TUNNEL ROOF: $t = 10"$ SPAN = 4'-11" $f'_c = 3,000 \text{ psi}$ ROOF LOAD: SOIL WT. = $110 \text{ pcf} \times 6.67' = 734 \text{ psf}$ CONC. WT. = $150 \text{ pcf} \times .83' = 125 \text{ psf}$ $W = 859 \text{ psf}$ TUNNEL ROOF MOMENT: $M_{\text{MAX}} = \frac{859(4.93)^2}{10} = 2,088 \text{ #}\cdot\text{ft}$ $S = \frac{12(10'')^2}{6} = 200.0 \text{ in}^3$ $M_{\text{CR}} = 410 \text{ psi} \times 200.0 \text{ in}^3 \times \frac{\text{ft}}{12 \text{ in}} = 6,833 \text{ #}\cdot\text{ft} > 2,088 \text{ #}\cdot\text{ft}$ TUNNEL CONC. ROOF CAN SUPPORT SOIL OVERBURDEN WITHOUT REINFORCEMENT.

Calculation Number

CALC - 881-PS-000050

Revision Number 0

B881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS4. SECOND FLOOR (EASTERN PAIR) VAULTS (AT MT-17)

(REF. TO DWG'S. (00327-0008) & (15835-0001)

VAULT ROOF: $t = 12''$ MIN $15''$ MAX SPANS = $24.0' \times 24.0'$ $f'_c = 3,000 \text{ psi}$

ROOF LOAD: SOIL WT. = $110 \text{ pcf} \times 3.5' = 385 \text{ psf}$
 CONC. WT. = $150 \text{ pcf} \times 1.25' = 188 \text{ psf}$
 573 psf

TUNNEL ROOF MOMENT:

$$(2\text{-WAY}) M_{\text{MAX}} = \left(\frac{573 (24.0)^2}{10} \right) / 2 = 16,502 \text{ #-FT}$$

$$S = 12'' (12.0')^2 / 6 = 288 \text{ in}^3 \quad f_r = 410 \text{ psi}$$

$$M_{CR} = 410 \text{ psi} \times 288 \text{ in}^3 \times \frac{\text{FT}}{12 \text{ in}} = 9,840 \text{ #-FT} < 16,502 \text{ #-FT}$$

TUNNEL CONCRETE ROOF CAN NOT SUPPORT SOIL
OVER-BURDEN WITHOUT REINFORCEMENT.

4. SECOND FLOOR (WESTERN PAIR) VAULTS (AT L-17 TO M-17)

(REF. TO DWG. (20507-0001)

TUNNEL ROOF: $t = 18''$ SPANS = $16.0' \times 16.0'$ $f'_c = 3,000 \text{ psi}$

ROOF LOAD: SOIL WT. = $110 \text{ pcf} \times 3.5' = 385 \text{ psf}$
 CONC. WT. $150 \text{ pcf} \times 1.5' = 225 \text{ psf}$
 610 psf

$$\text{TUNNEL ROOF MOMENT: } M_{\text{MAX}} = \left(\frac{610 (16.0)^2}{10} \right) / 2 = 7,808 \text{ #-FT}$$

$$S = 12 (12)^2 / 6 = 288 \text{ in}^3 \quad f_r = 410 \text{ psi}$$

$$M_{CR} = 410 \text{ psi} \times 288 \text{ in}^3 \times \frac{\text{FT}}{12 \text{ in}} = 9,840 \text{ #-FT} > 7,808 \text{ #-FT}$$

TUNNEL CONCRETE ROOF CAN SUPPORT SOIL
OVERBURDEN WITHOUT REINFORCEMENT.

Calculation Number

CALC - 881 - BS - 000050

Revision Number 0

881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS51 SECOND FLOOR TUNNEL FROM 881 TO 883 (AT A-20)TUNNEL ROOF: $t = 12"$ SPAN = 8.0' $f'_c = 3000 \text{ psi}$ ROOF LOAD: SOIL WT. = $110 \text{ pcf} \times 7.0' = 770 \text{ psf}$ CONC. WT. = $150 \text{ pcf} \times 1.0' = 150 \text{ psf}$

920 psf

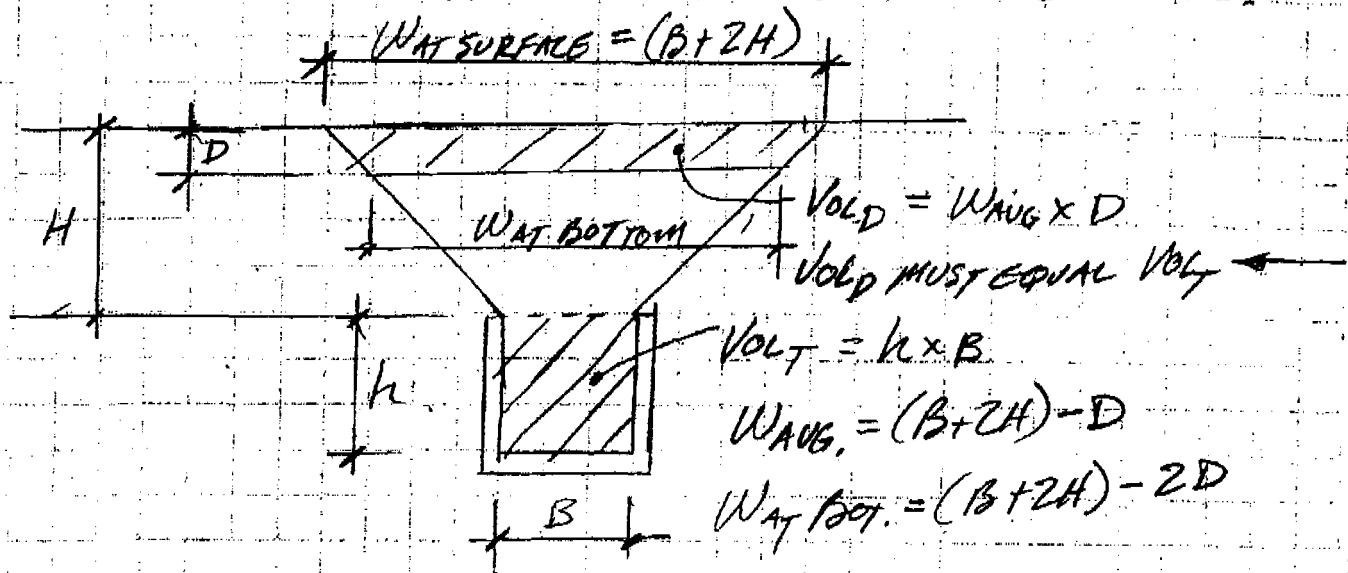
TUNNEL ROOF MOMENT: $M_{\text{max}} = \frac{920 (8.0)^2}{10} = 5,888 \text{ #-ft}$ $S = 12 (12.0')^3 / 6 = 288 \text{ in}^3 \times \frac{\text{psi}}{12 \text{ in}} = 9,840 \text{ #-ft} > 5,888 \text{ #-ft}$ TUNNEL CONCRETE ROOF CAN SUPPORT SOIL
OVERBURDEN WITHOUT REINFORCEMENT.

RFETS	ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE	Calculation Sheet	Page 13 of 47
Calculation Number	CALC - 881-BS-00050	Revision Number	0

B881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS

DEPRESSION CALC. AFTER TUNNELS & VAULTS COLLAPSE

ASSUME SOIL SETTLES AT 45° FROM INSIDE EDGES.



① BOILER TUNNEL: $B = 7.0'$ $H = 7.0'$ $H = 9.67'$

$$Vol_T = 7.0' \times 7.0' = 49.0 \text{ ft}^2 \quad W_{AUG} = 7.0' + (2 \times 9.67') - D$$

$$= 26.34' - D$$

TRY: $D = 2.0'$ $Vol_D = 2.0' \times (26.34' - 2.0')$

$$= 48.68 \text{ ft}^2 \text{ O.K.}$$

DEPRESSION = $\frac{2.0 \text{ DEEP} \times 26.34' \text{ WIDE AT SURFACE}}{\times 22.34' \text{ WIDE AT BOTTOM}}$

② FIRST FLOOR EXHAUST TUNNEL: $B = 12.0'$ $H = 15.0'$ $H = 16.83'$

$$Vol_T = 12.0' \times 15.0' = 180.0 \text{ ft}^2 \quad W_{AUG} = 12.0' + (2 \times 16.83') - D$$

$$= 45.7' - D$$

TRY: $D = 4.4'$ $Vol_D = 4.4' \times (45.7' - 4.4') = 186.7 \text{ ft}^2 \text{ O.K.}$

DEPRESSION = $\frac{4.4' \text{ DEEP} \times 45.7' \text{ WIDE AT SURFACE}}{\times 36.9' \text{ WIDE AT BOTTOM}}$

Calculation Number

CALC - 881-BS-000050

Revision Number 0

B881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUCT. ANALYSIS

DEPRESSION CALCS. - CONTINUED

(3) SECOND FLOOR EXHAUST TUNNEL: $B = 4.9'$ $h = 5.4'$ $H = 6.7'$

$$VOL_T = 4.9' \times 5.4' = 26.5 \text{ ft}^2 \quad W_{AVG.} = 4.9' + (2 \times 6.7') - D$$

$$\text{TRY } D = 1.5' \quad = 18.3' - D$$

$$VOL_D = 1.5' \times (19.0' - 1.5') = 26.25 \text{ ft}^2 \text{ O.K.}$$

DEPRESSION - 1.5' DEEP \times 18.3' WIDE AT SURFACE
 \times 15.3' WIDE AT BOTTOM

(4.0) SECOND FLOOR VAULTS (EASTERN PAIR):

$$B = 24.0' \times 24.0' \quad h = 12.0' \quad H = 3.5'$$

$$VOL_{VAULT} = 24.0' \times 24.0' \times 12.0' = 6,912 \text{ ft}^3$$

$$W_{AVG.} = 24.0' + (2 \times 3.5') - D = 31.0' - D$$

TRY: $D_{MAX} = H$

$$VOL_D = (31.0' - 3.5')^2 \times 3.5' = 2,647 \text{ ft}^3 < 6,912 \text{ ft}^3$$

THE DEPRESSION SOIL DOES NOT FILL THE VAULT.
 THERE WILL BE A HOLE AT THE UNFILLED VAULTS.

HOLE DEPTH IN VAULT h'

$$h' = (6,912 \text{ ft}^3 - 2,647 \text{ ft}^3) / (24.0')^2 = 7.4'$$

DEPRESSIONS = 3.5' DEEP \times 31 ft \times 31 ft AT THE SURFACEHOLE AT UNFILLED VAULT = 7.4' DEEP \times 24.0' \times 24.0'

$$\text{TOTAL DEPTH} = 3.5' + 7.4' = 10.9' \text{ SAY } 11.0' \leftarrow$$

Calculation Number

CALC - 881 - BS - 000050

Revision Number 0

B881 TUNNELS, STACK FOUNDATIONS & VAULTS STRUC. ANALYSISDepression Chcs.4.0 SECOND FLOOR VAULTS (WESTERN PAIR)

$$B = 16.0' \times 16.0' \quad h = 12.0' \quad H = 3.5'$$

$$Vol_{VAULT} = 16.0' \times 16.0' \times 12.0' = 3,072 \text{ ft}^3$$

$$W_{ANG} = 16.0' + (2 \times 3.5') - D = 23.0' - D$$

$$TRY D_{MAX} = H = 3.5'$$

$$Vol_D = (23.0' - 3.5')^2 \times 3.5' = 1,331 \text{ ft}^3 < 3,072 \text{ ft}^3$$

THE DEPRESSION SOIL DOES NOT FILL VAULT

THERE WILL BE A HOLE AT THE UNFILLED VAULTS

$$HOLE DEPTH h' = (3,072 \text{ ft}^3 - 1,331 \text{ ft}^3) / (16.0')^2 = 6.8' \text{ DEEP}$$

DEPRESSION = 3.5' DEEP \times 23.0' \times 23.0' AT SURFACEVAULT HOLE = 6.8' DEEP \times 16.0' \times 16.0' TOTAL DEPTH = 3.5' + 6.8' = 10.3'5.0 SECOND FLOOR TUNNEL FROM 881 TO 883

$$B = 8.0' \quad h = 10.0' \quad H = 4.0'$$

$$Vol_{TUNNEL} = 8.0' \times 10.0' = 80 \text{ ft}^2$$

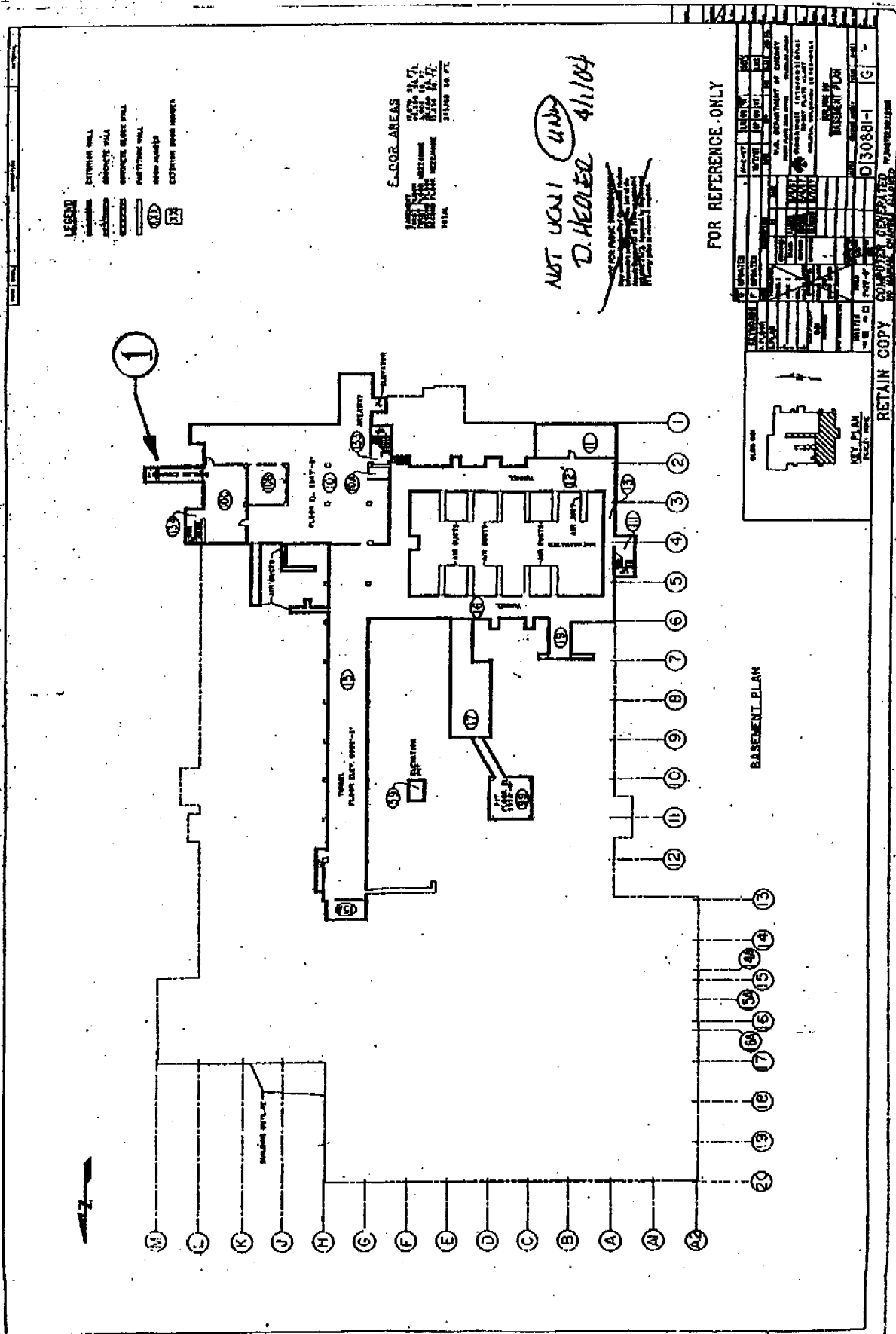
$$W_{ANG} = 8.0' + (2 \times 4.0') - D = 16.0' - D$$

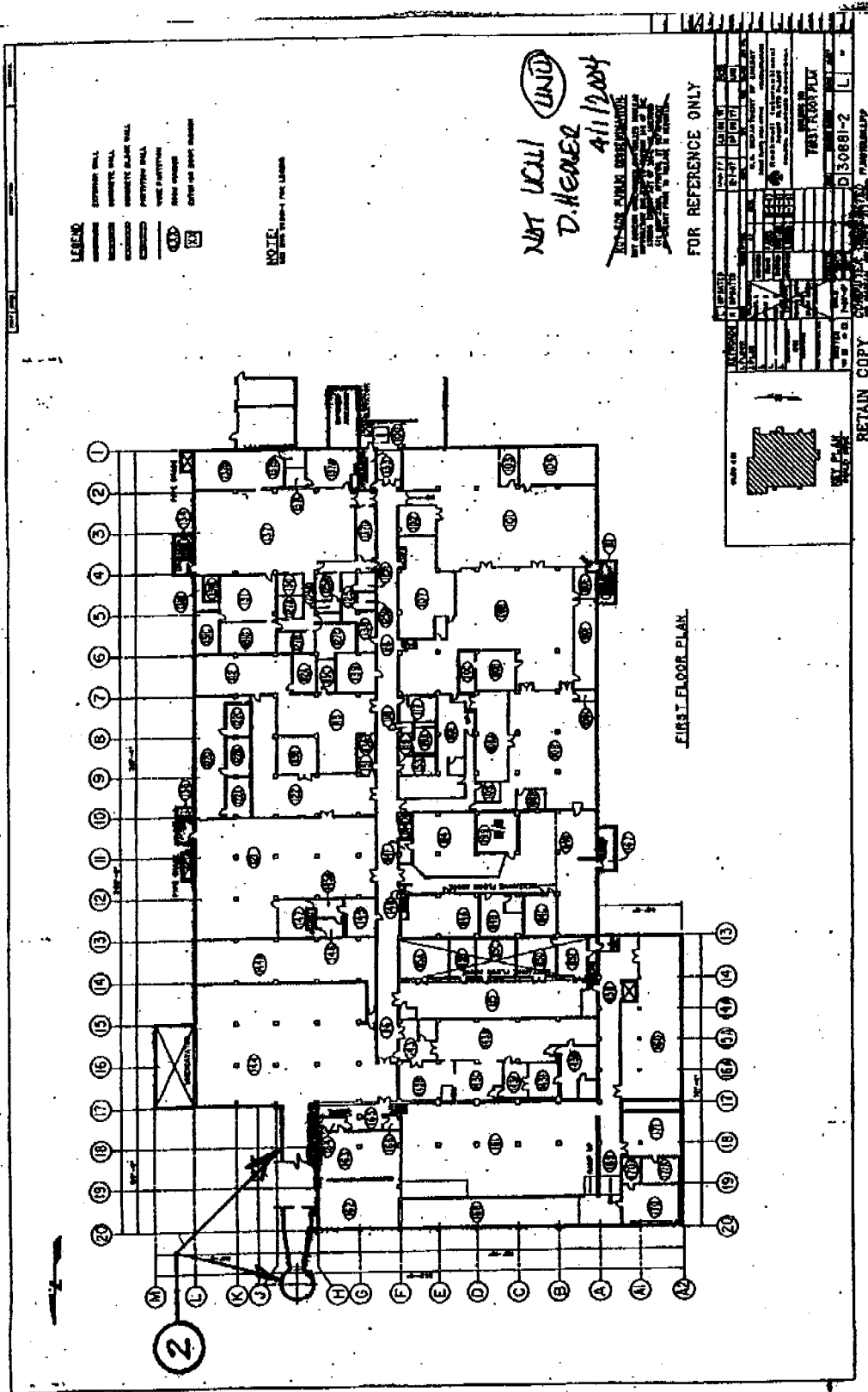
$$TRY D_{MAX} = H = 4.0' \quad Vol_D = 4.0' (16.0' - 4.0') = 48.0 \text{ ft}^2 < 80.0 \text{ ft}^2$$

THERE WILL BE A HOLE AT UNFILLED TUNNEL

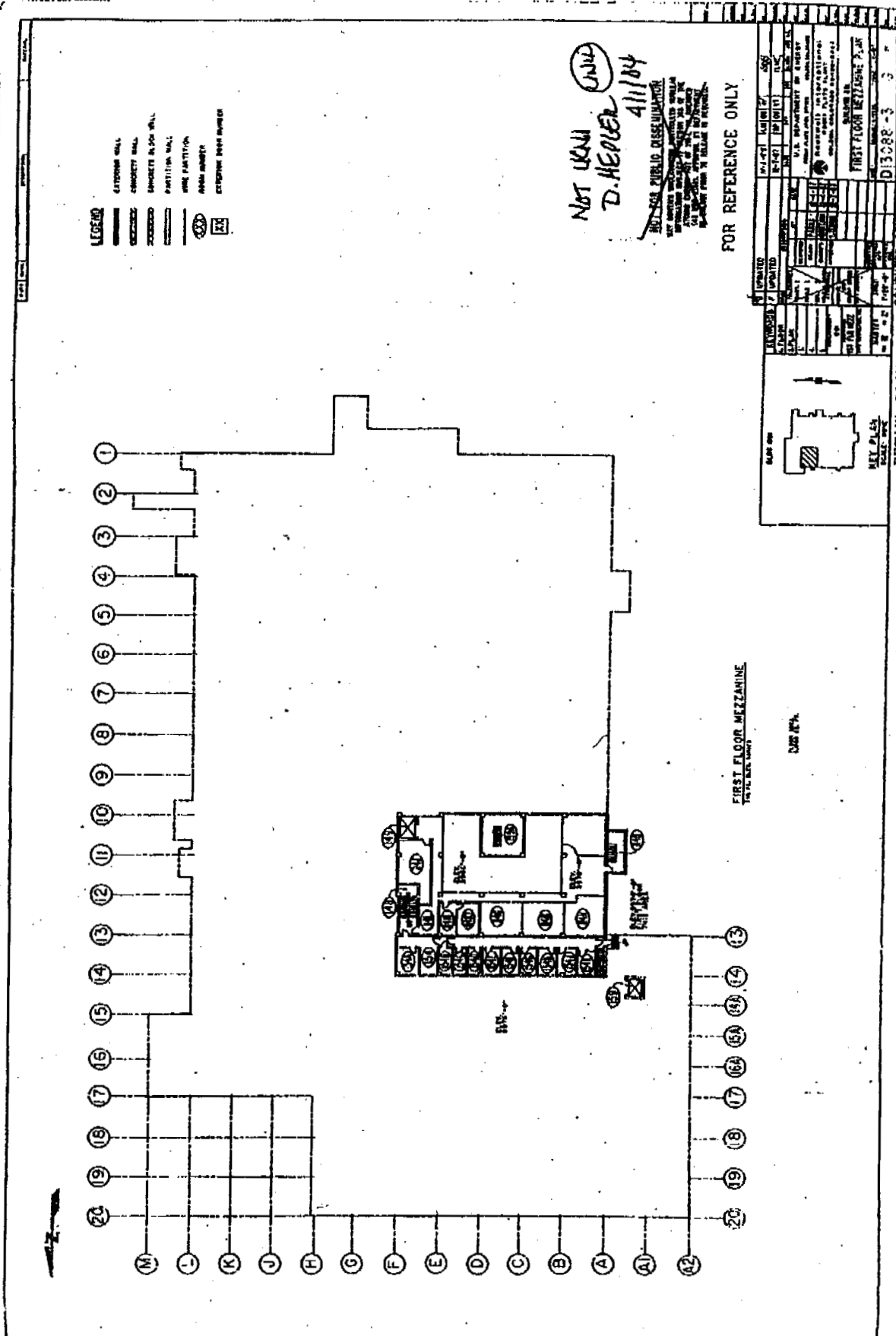
$$HOLE DEPTH h' = (80 \text{ ft}^2 - 48.0') / 8.0' \\ = 4.0' \text{ DEEP} \times 8.0' \text{ WIDE}$$

DEPRESSION 4.0' DEEP \times 16.0' WIDE AT SURFACE

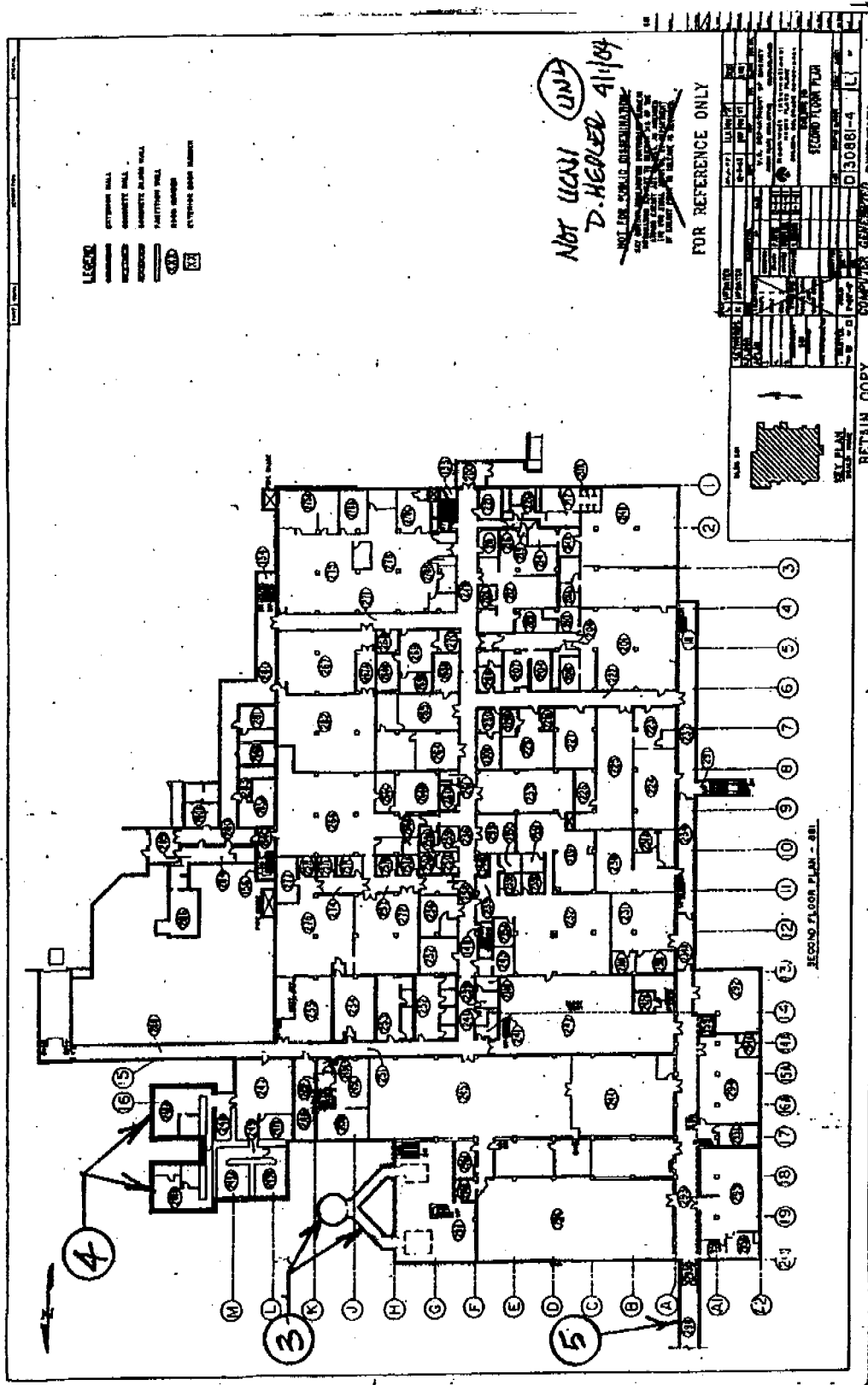




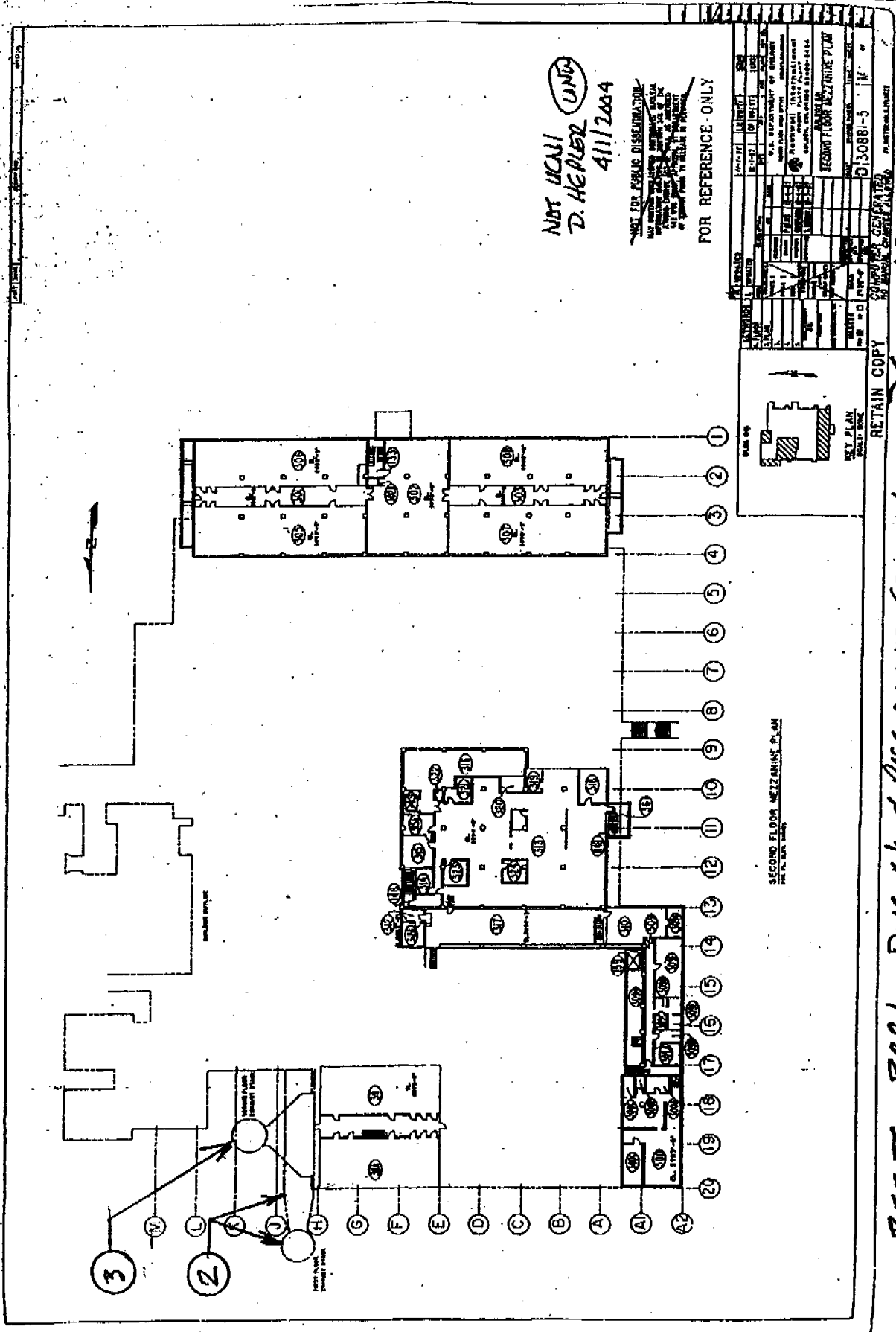
REFGTS 8881 DWG. No. 4 Disopune (30881-0002) (Arch.)

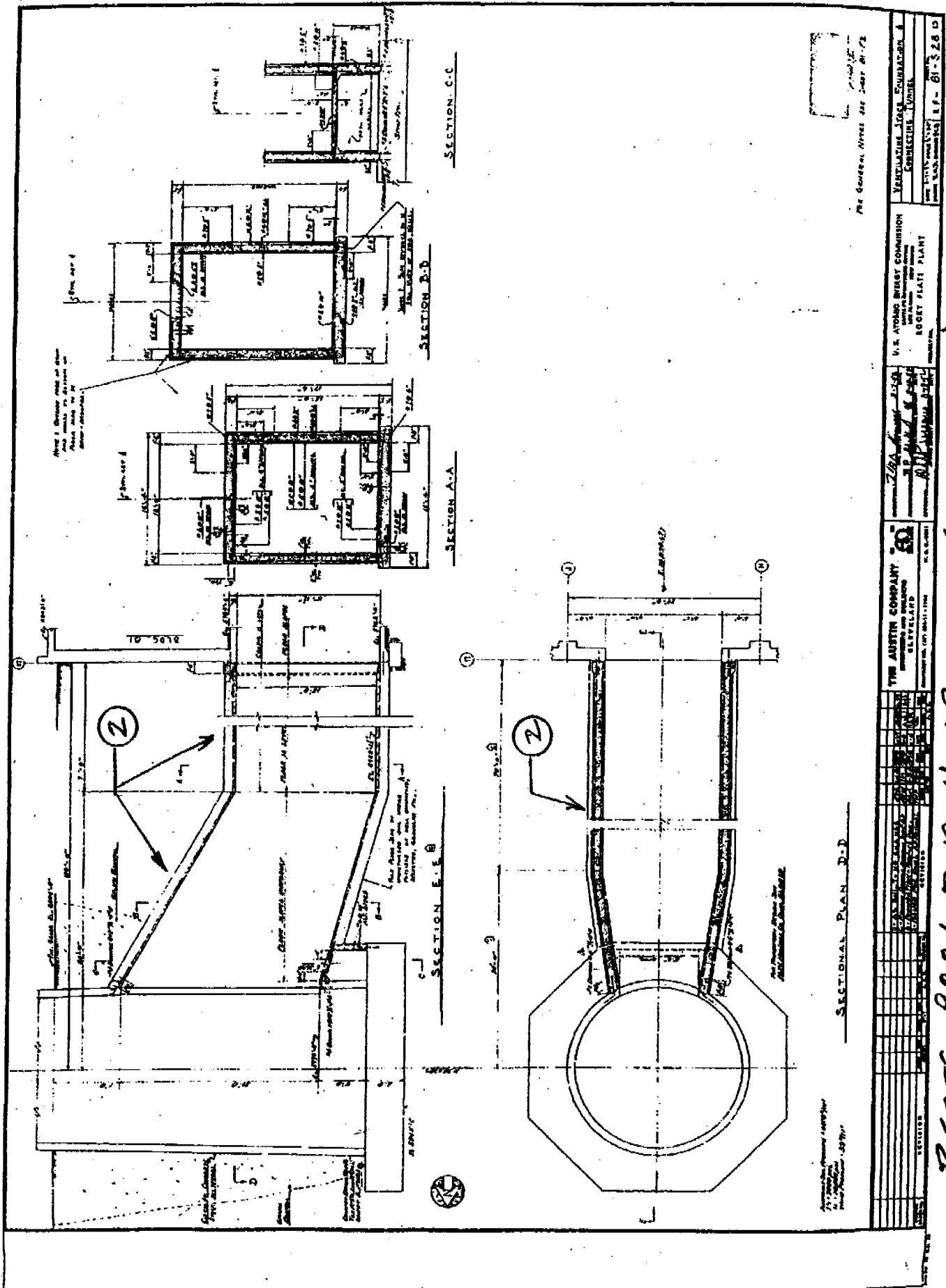


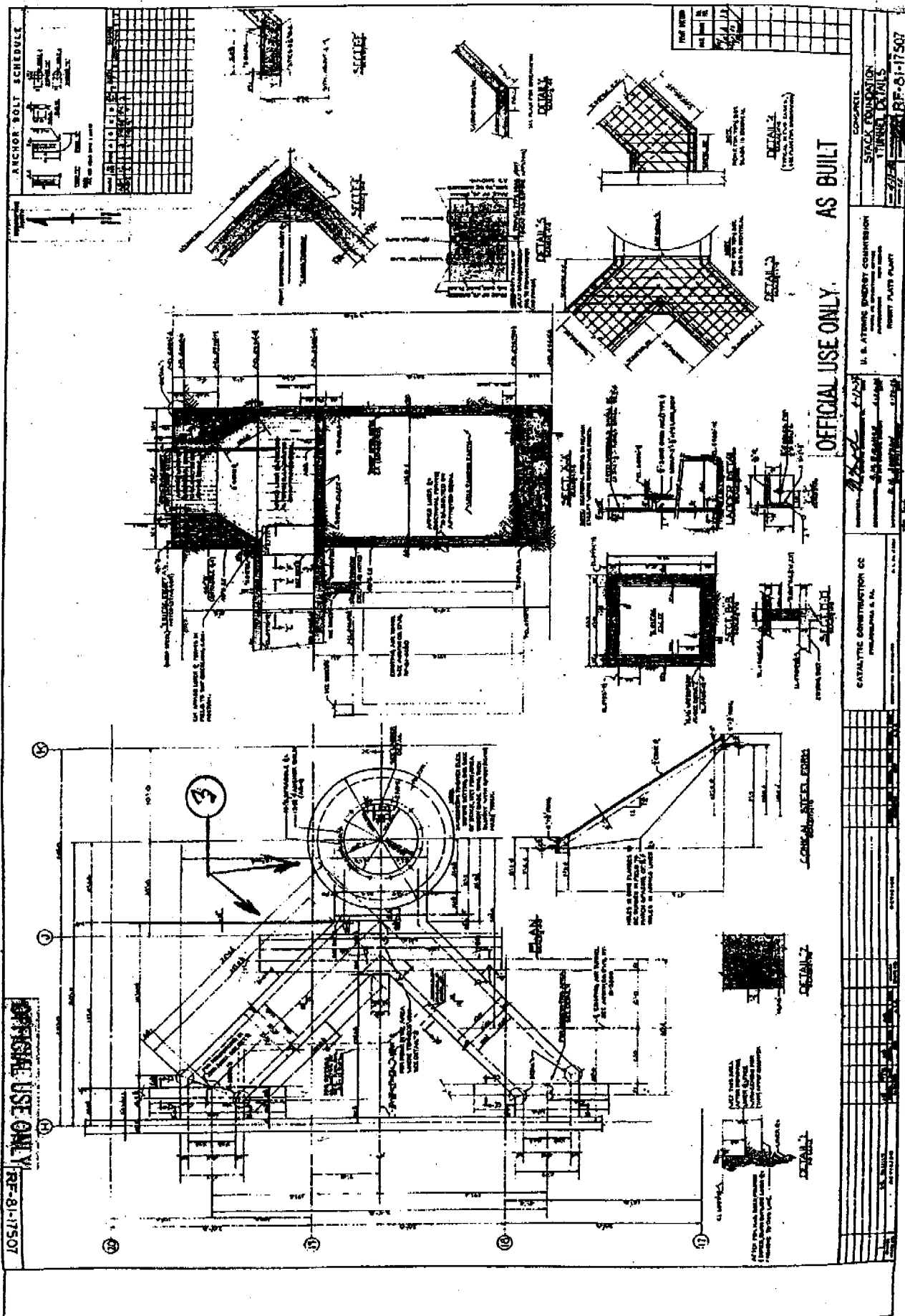
REFS 6881 DAB; No. 8 DISCIPLINE (30881-0003) (ARCH.)



RFETS BOB / Pub. No. 8 Discipline (30881-0004) (ARCH)



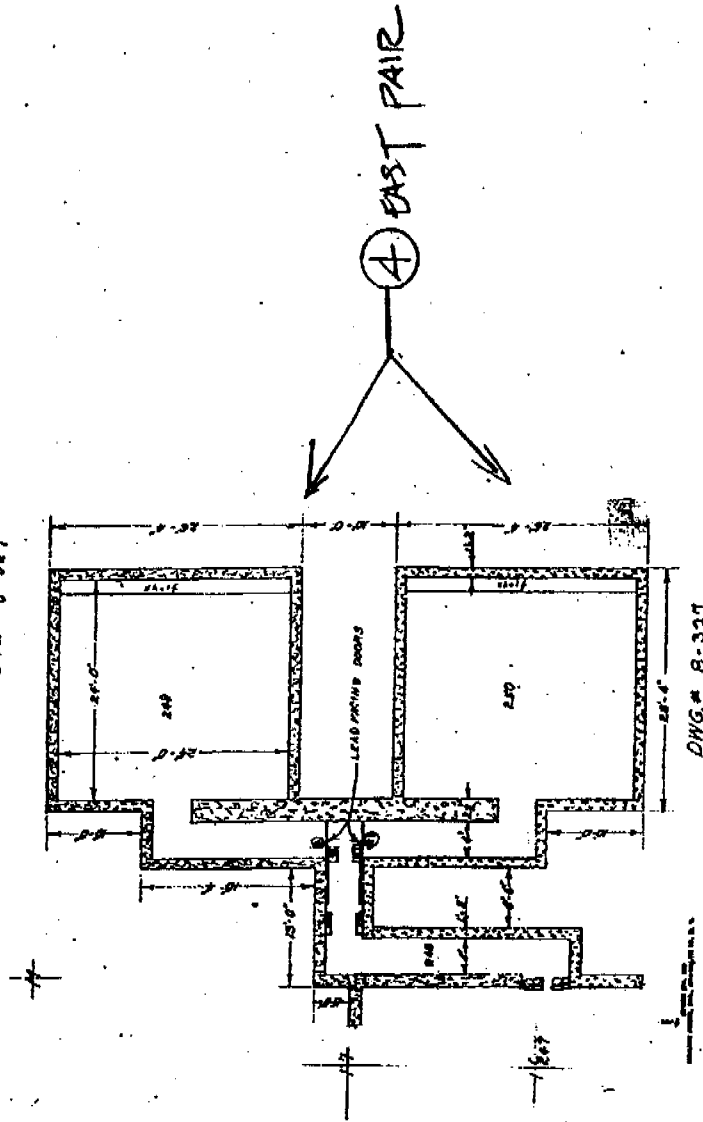




R F E T S B B B 1 D A W G. N O. # D I S C I P L I N E (1 7 5 0 7 - 0 0 0 2) (U N K N O W N)

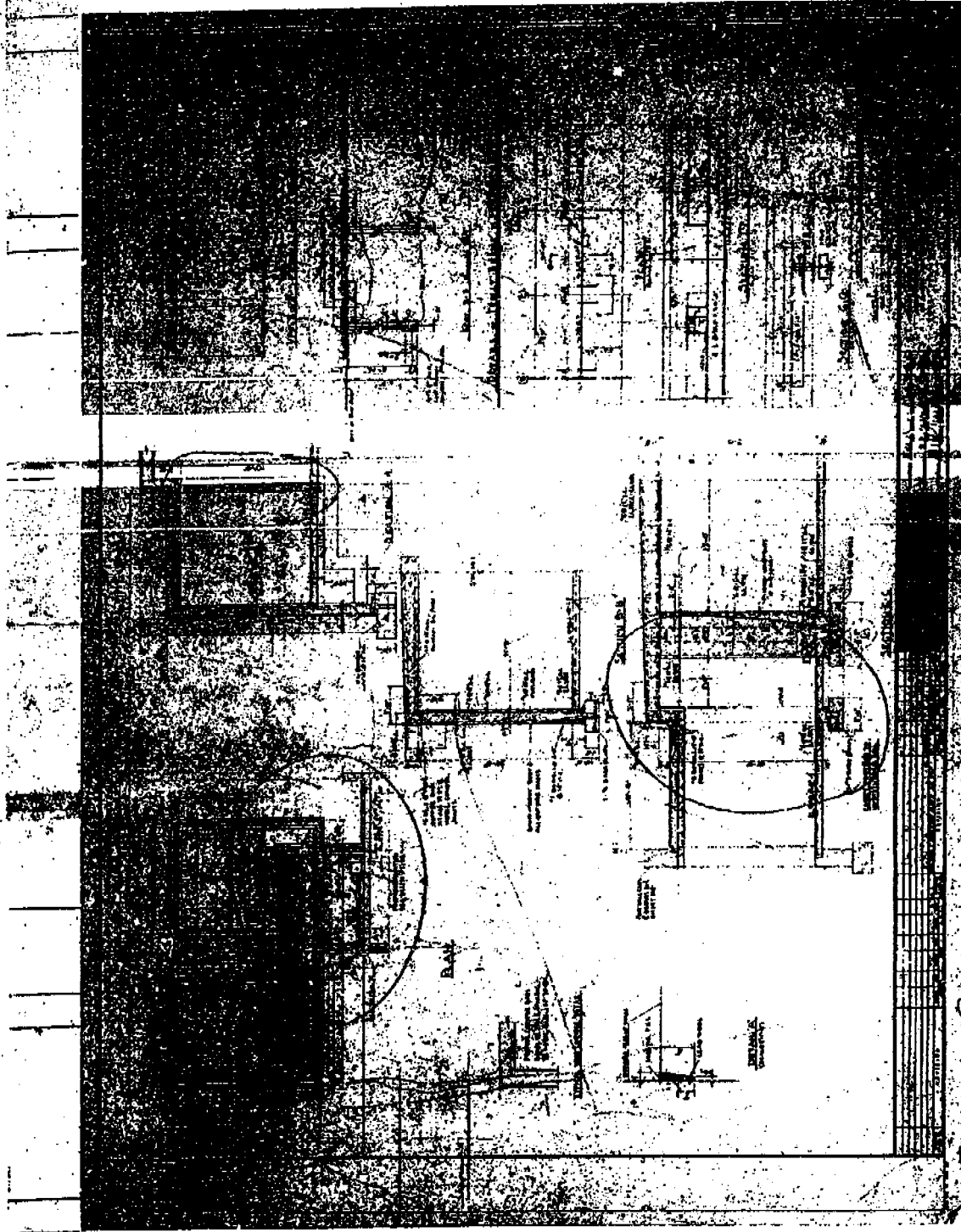
THE BOW CHURCH COMPANY
ALL WORKING DRAWINGS
SHALL BE MADE
IN ACCORDANCE
WITH THE
FOLLOWING

NAME: Radiographic Unit, Room 248, 249 & 250
DWG. # 8-327
+ DWG. # 8-327



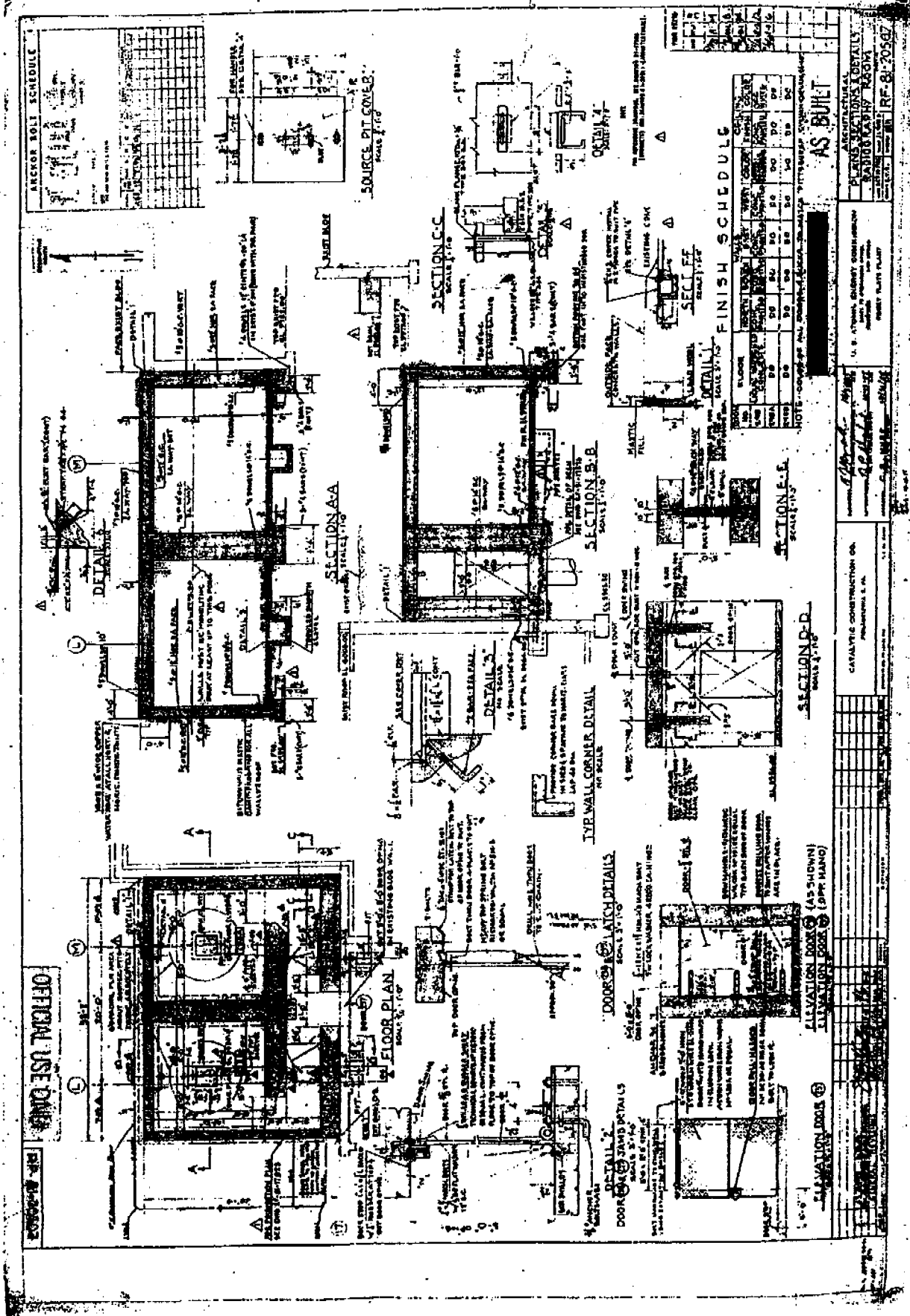
RADIOGRAPHIC UNIT, ROOMS 248, 249 & 250
REFS B881 DWG. No. 8 Discipline (00327-0000) (BUILDING)

④ EAST PAIR

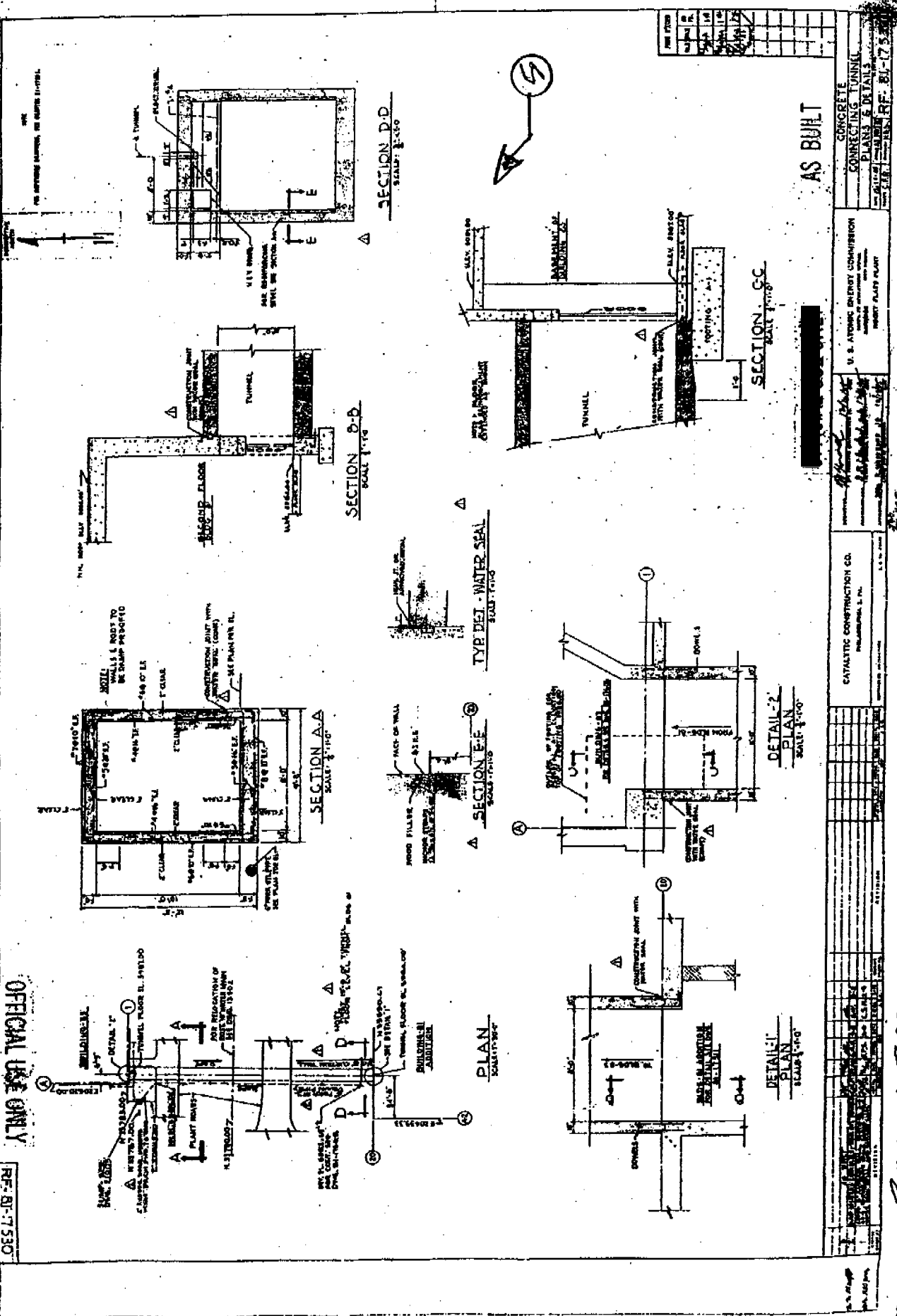


Plans & Concrete Details Rm 248, 249 & 250
RFETS 8881 DWG. No. 4 Duplone (15835-0001) (BUILDING)

④ WEST PAIR



RFETS 8881 DWG. No. 4 Disruption (20507-0001) (Acct.)



RPETS B881 DWG. No. & DISCIPLINE (17530-0002) (MECHANICAL)

NOTE: SEE CAP. V. 135-136 FOR STATEMENT

GENERAL NOTES

[illegible]

ГОУ ВПО «СГАУ»

[illegible]

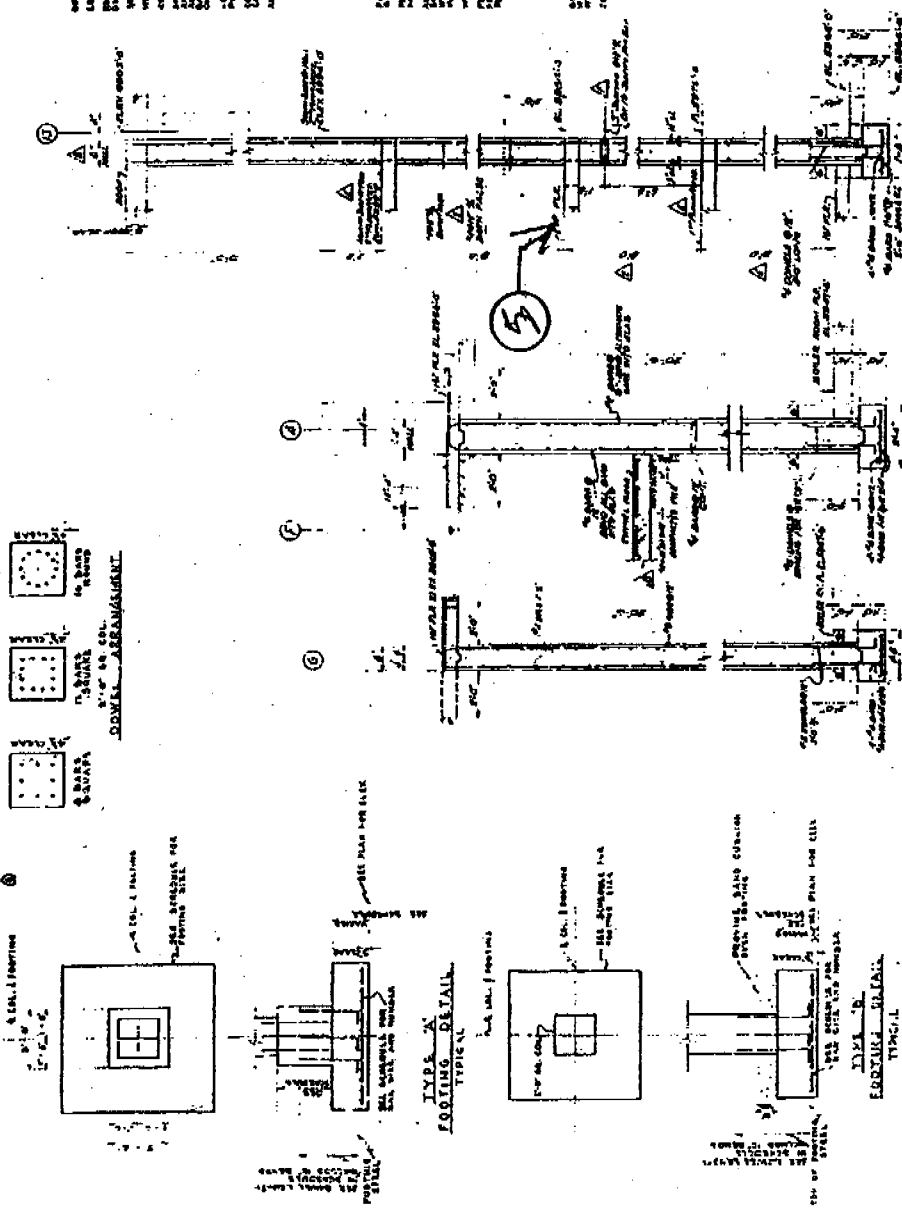
1985-1986

MAILING ADDRESS: 10000 100th Ave, NE, Redmond, WA 98073-1500
 PHONE: (206) 881-1111
 FAX: (206) 881-1112
 E-MAIL: info@redmond.gov
 WEBSITE: www.redmond.gov

DESIGN

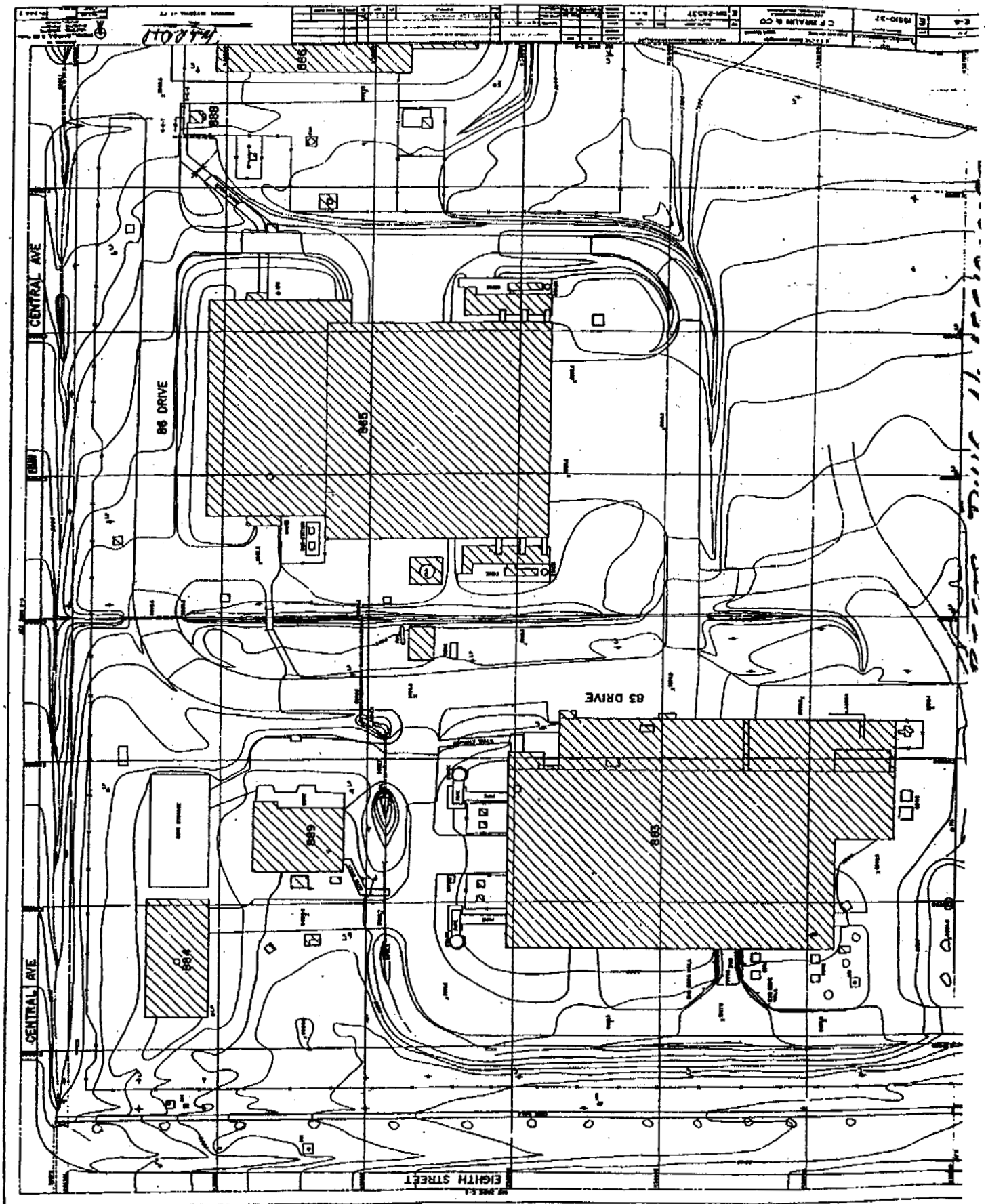
SAFE S&P BLANKING JUGS 100000
SAFE S&P BLANKING JUGS 100000
STAINLESS S&P BLANKING JUGS 100000
STAINLESS S&P BLANKING JUGS 100000

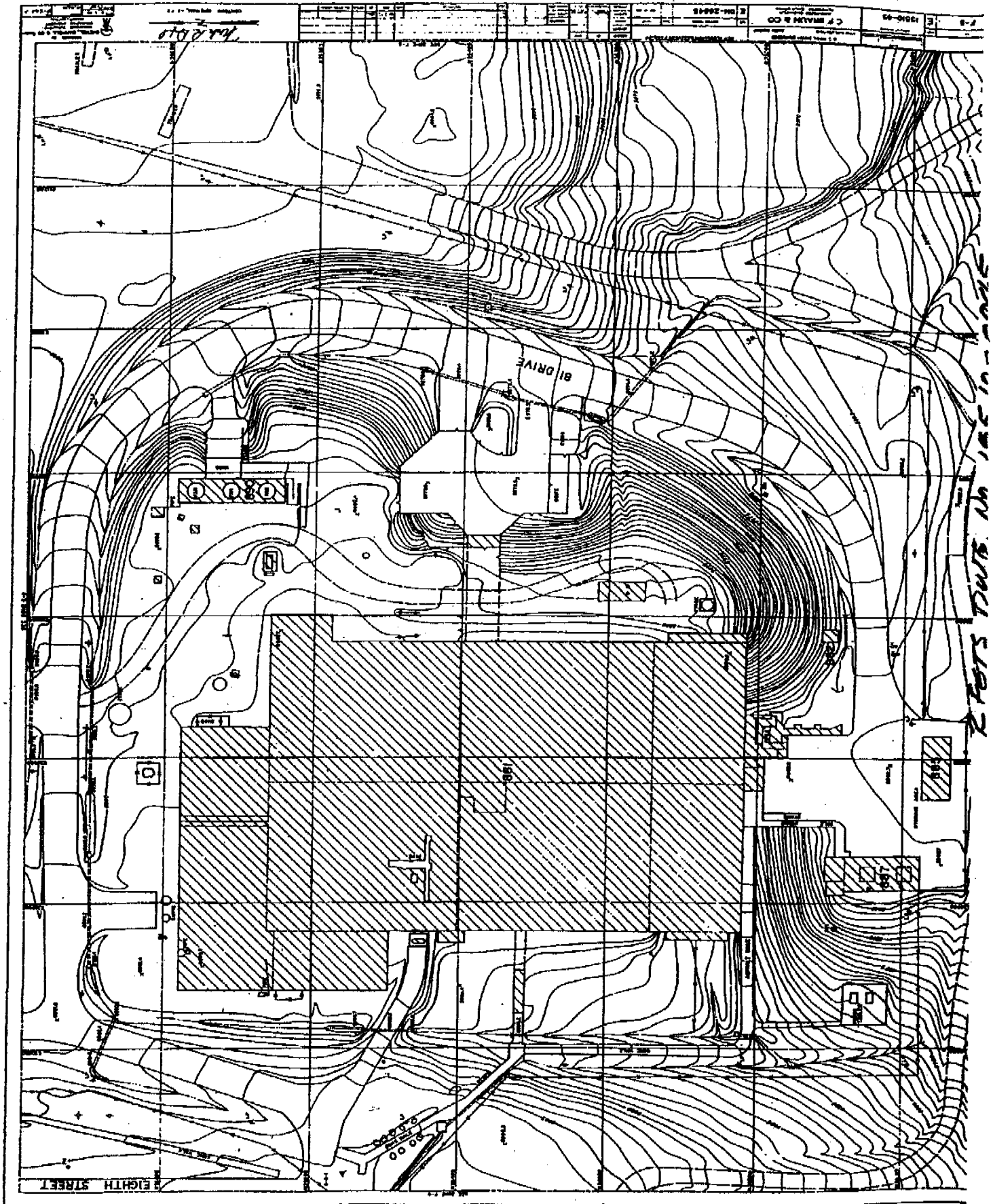
A = 1000 P/L
B = 1000 P/L
C = 1000 P/L
D = 1000 P/L

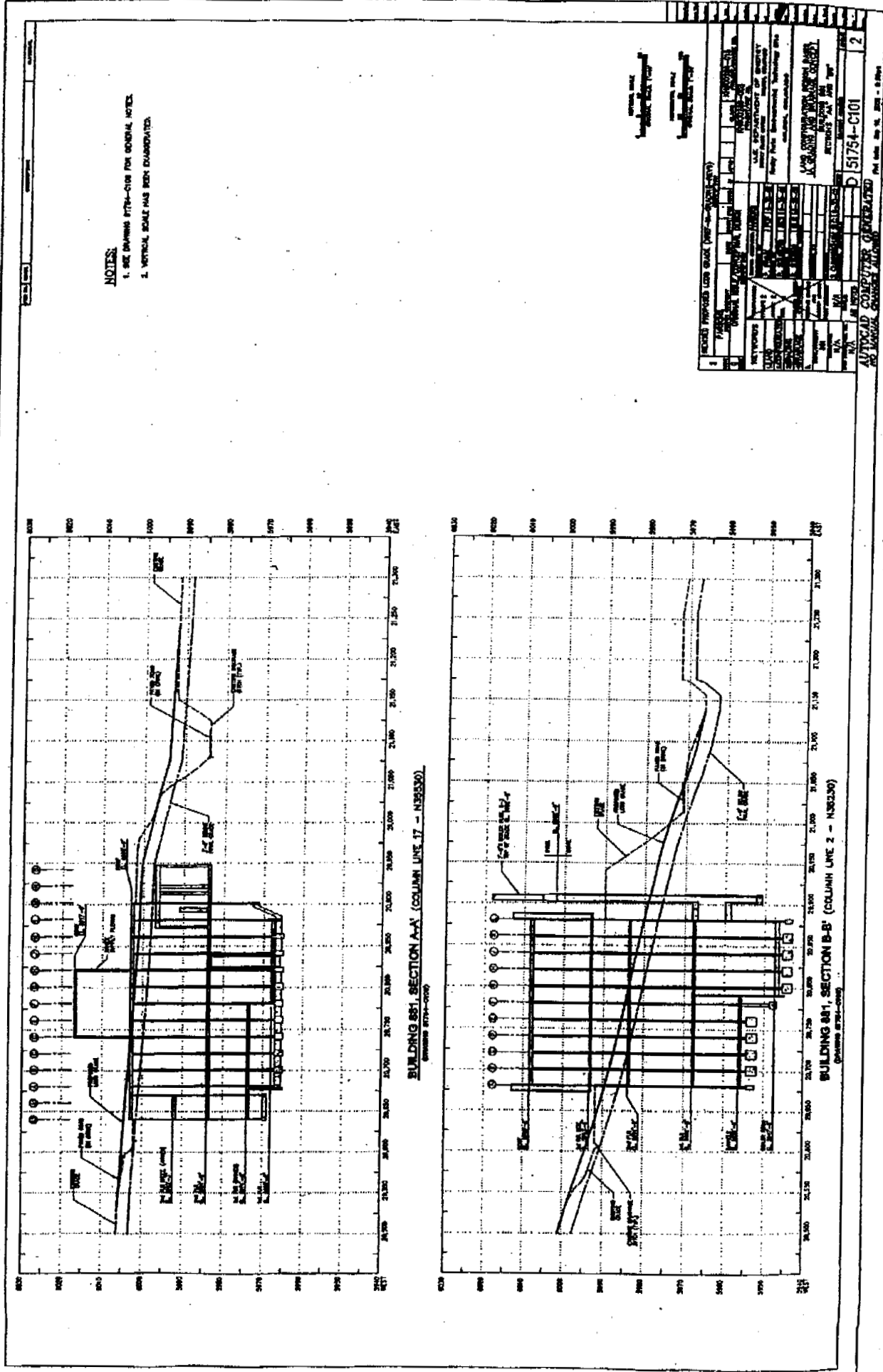


1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
<div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>THE AUSTIN COMPANY <small>MANUFACTURERS OF</small> ROCKET PLAYS <small>INCORPORATED</small> ROCKET PLAYS <small>INCORPORATED</small></p> </div> <div style="width: 50%;"> <p>U.S. ARMS ENERGY COMBUSTION <small>INCORPORATED</small> ROCKET PLAYS <small>INCORPORATED</small></p> </div> </div> <div style="display: flex; justify-content: space-between; margin-top: 10px;"> <div style="width: 45%;"> <p>THE AUSTIN COMPANY <small>MANUFACTURERS OF</small> ROCKET PLAYS <small>INCORPORATED</small> ROCKET PLAYS <small>INCORPORATED</small></p> </div> <div style="width: 50%;"> <p>U.S. ARMS ENERGY COMBUSTION <small>INCORPORATED</small> ROCKET PLAYS <small>INCORPORATED</small></p> </div> </div>																																																																																																			

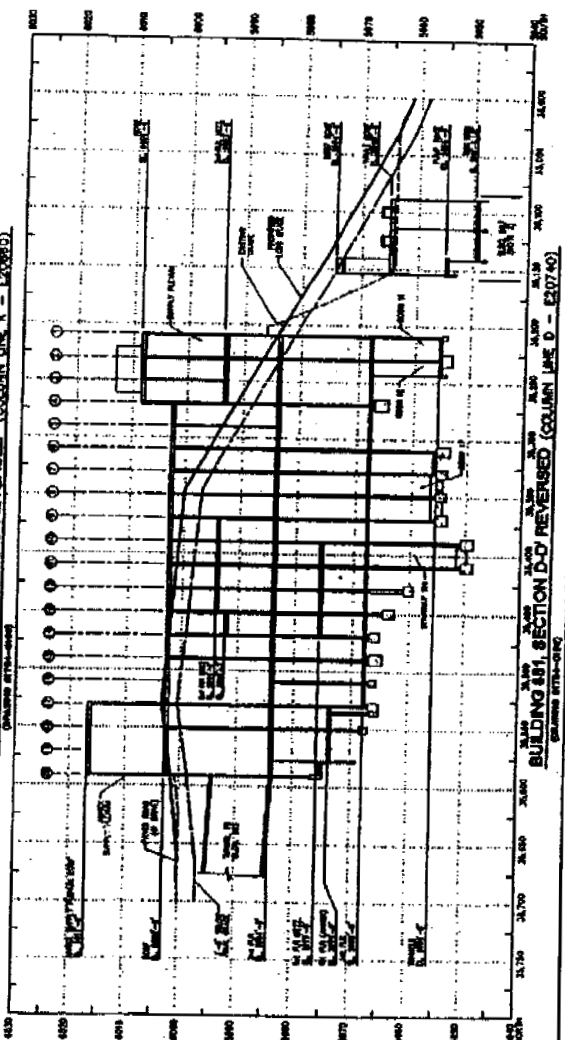
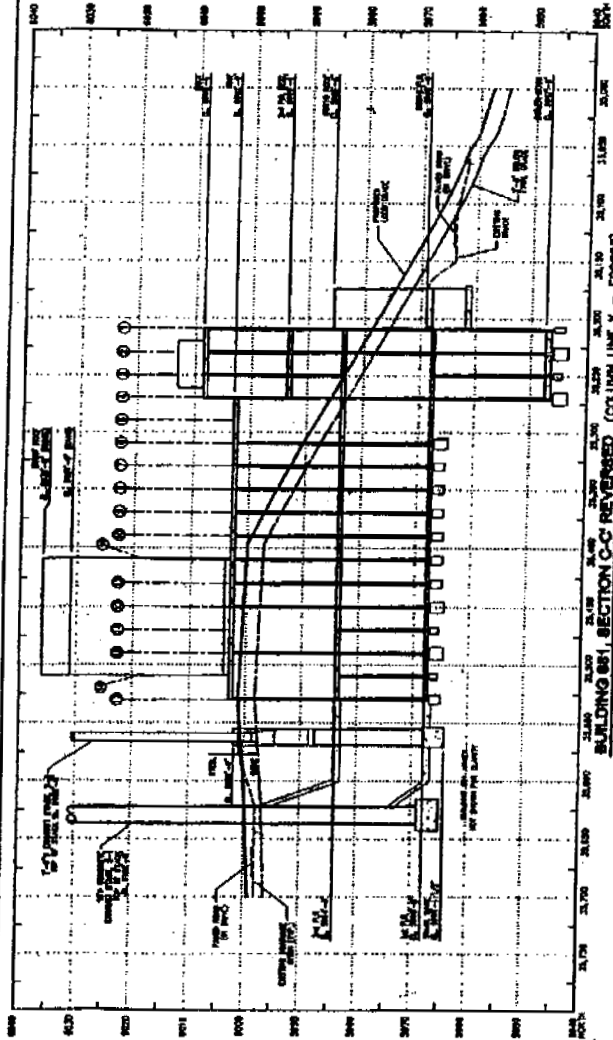
REFS B881 Dwt. n. & Discrepan (00F02-001F) (Bumang)







61



- NOTES**
1. SEE DRAWING 87754-C102 FOR GENERAL NOTES.
 2. VERTICAL SCALE HAS BEEN EXAGGERATED.
 3. PROPOSED LIFTING CRANE SHOWN IS OFFSET TO CLASH THE SPACE THAT WOULD BE PROVIDED OVER BUILDING 881.

NOTES
 1. SEE DRAWING 87754-C102 FOR GENERAL NOTES.
 2. VERTICAL SCALE HAS BEEN EXAGGERATED.
 3. PROPOSED LIFTING CRANE SHOWN IS OFFSET TO CLASH THE SPACE THAT WOULD BE PROVIDED OVER BUILDING 881.

PROJECT: BUILDING 881, SECTION C-C REVERSED (COLUMN LINE K - EXPOSED)		DATE: 10/15/88	
DRAWN BY: [Name]		CHECKED BY: [Name]	
DESIGNED BY: [Name]		APPROVED BY: [Name]	
PROJECT NO.: 87754-C102		SHEET NO.: 2	
AUTOCAD COMPUTER GENERATED		NO SCALE CHANGES ALLOWED	

CALC-881-B8-000050

PAGE 33 OF 47

CALC-881-3S-000050

PAGE 34 OF 47

ACI 318-89
ACI 318R-89

Building Code Requirements
for Reinforced Concrete
Structures
and Commentary - ACI 318-89



CODE

flexion shall be computed with the modulus of elasticity E_c for concrete as specified in 8.5.1 (normal weight or lightweight concrete) and with the effective moment of inertia as follows, but not greater than I_g :

$$I_e = \left(\frac{M_{cr}}{M_a} \right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a} \right)^3 \right] I_{cr} \quad (9-7)$$

where

$$M_{cr} = \frac{f_r I_g}{y_t} \quad (9-8)$$

and for normal weight concrete,

$$f_r = 7.5 \sqrt{f'_c} \quad (9-9)$$

When lightweight aggregate concrete is used, one of the following modifications shall apply:

(a) When f_{ct} is specified and concrete is proportioned in accordance with 5.2, f_r shall be modified by substituting $f_{ct}/6.7$ for $\sqrt{f'_c}$, but the value of $f_{ct}/6.7$ shall not exceed $\sqrt{f'_c}$.

(b) When f_{ct} is not specified, f_r shall be multiplied by 0.75 for "all-lightweight" concrete, and 0.85 for "sand-lightweight" concrete. Linear interpolation is permitted if partial sand replacement is used.

9.5.2.4 – For continuous members, effective moment of inertia may be taken as the average of values obtained from Eq. (9-7) for the critical positive and negative moment sections. For prismatic members, effective moment of inertia may be taken as the value obtained from Eq. (9-7) at midspan for simple and continuous spans, and at support for cantilevers.

9.5.2.5 – Unless values are obtained by a more comprehensive analysis, additional long-term deflection resulting from creep and shrinkage of flexural members (normal weight or lightweight concrete) shall be determined by multiplying the immediate deflection caused by the sustained load considered, by the factor

$$\lambda = \frac{\xi}{1 + 50\rho'} \quad (9-10)$$

where ρ' shall be the value at midspan for simple and continuous spans, and at support for cantilevers. It is permitted to assume the time-dependent factor ξ for sustained loads to be equal to

COMMENTARY

selected as being sufficiently accurate for use to control deflections.^{9,7-9,10} The effective I_e was developed to provide a transition between the upper and lower bounds of I_g and I_{cr} as a function of the ratio M_{cr}/M_a . For most practical cases I_e will be less than I_g .

R9.5.2.4 – For continuous members, the code procedure suggests a simple averaging of I_e values for the positive and negative moment sections. The use of the midspan section properties for continuous prismatic members is considered satisfactory in approximate calculations primarily because the midspan rigidity (including the effect of cracking) has the dominant effect on deflections, as shown by ACI Committee 435^{9,10,9,11} and SP-43.^{9,4}

R9.5.2.5 – Shrinkage and creep due to sustained loads cause additional "long term deflections" over and above those which occur when loads are first placed on the structure. Such deflections are influenced by temperature, humidity, curing conditions, age at time of loading, quantity of compression reinforcement, magnitude of the sustained load, and other factors. The expression given in this section is considered satisfactory for use with the code procedures for the calculation of immediate deflections, and with the limits given in Table 9.5(b).^{9,12} It should also be noted that the deflection computed in accordance with this section is the additional long-term deflection due to the dead load and that portion of the live load which will be sustained for a sufficient period to cause significant time-dependent deflections.

CODE

COMMENTARY

met regardless of whether the strength method or the alternate method is used for design.

A.2 – General

A.2.1 – Load factors and strength reduction factors ϕ shall be taken as unity for members designed by the Alternate Design Method.

A.2.2 – Members may be proportioned for 75 percent of capacities required by other parts of Appendix A when considering wind or earthquake forces combined with other loads, provided the resulting section is not less than that required for the combination of dead and live load.

A.2.3 – When dead load reduces effects of other loads, members shall be designed for 85 percent of dead load in combination with the other loads.

A.3 – Permissible service load stresses

A.3.1 – Stresses in concrete shall not exceed the following:

(a) Flexure

Extreme fiber stress
in compression $0.45 f'_c$

(b) Shear*

Beams and one-way slabs and footings:
Shear carried by concrete, v_c $1.1 \sqrt{f'_c}$

Maximum shear
carried by concrete plus shear
reinforcement $v_c + 4.4 \sqrt{f'_c}$

Joists†

Shear carried by concrete, v_c $1.2 \sqrt{f'_c}$

RA.2 – General

RA.2.1 – Load factors and strength reduction factors for determining safety in the Strength Design Method are not used in the Alternate Design Method. Accordingly, load factors and strength reduction factors ϕ are set equal to 1.0 to eliminate their effect when designing by the alternate method.

When using the moment and shear equations of 8.3.3 and Chapter 13, the factored load w_u must be replaced by the service load w .

RA.2.2 – When lateral loads such as wind or earthquake combined with live and dead load govern the design, members may be proportioned for 75 percent of capacities required in Appendix A. This is similar to the working stress design provisions of previous ACI Building Codes which allowed a one-third increase in stresses for these combinations of loads.

RA.2.3 – The 15 percent reduction for dead load is required for design conditions where dead load reduces the design effects of other loads to allow for the actual dead load being less than the dead load used in design. This provision is analogous to the required strength equation [Eq. (9-3)].

RA.3 – Permissible service load stresses

For convenience, permissible service load stresses are tabulated. Compressive stress in concrete for flexure without axial load is limited to $0.45 f'_c$. Tensile stresses in reinforcement are limited to 20,000 psi for Grade 40 and 50 steel and 24,000 psi for Grade 60 and higher strength steel. One exception of long standing exists for one-way slabs with clear span lengths 12 ft or less and reinforced with #3 bars or welded wire fabric having a diameter not exceeding 3/8 in. For this design condition only, the permissible tensile stress is increased to the lesser of $0.5 f_y$ or 30,000 psi.

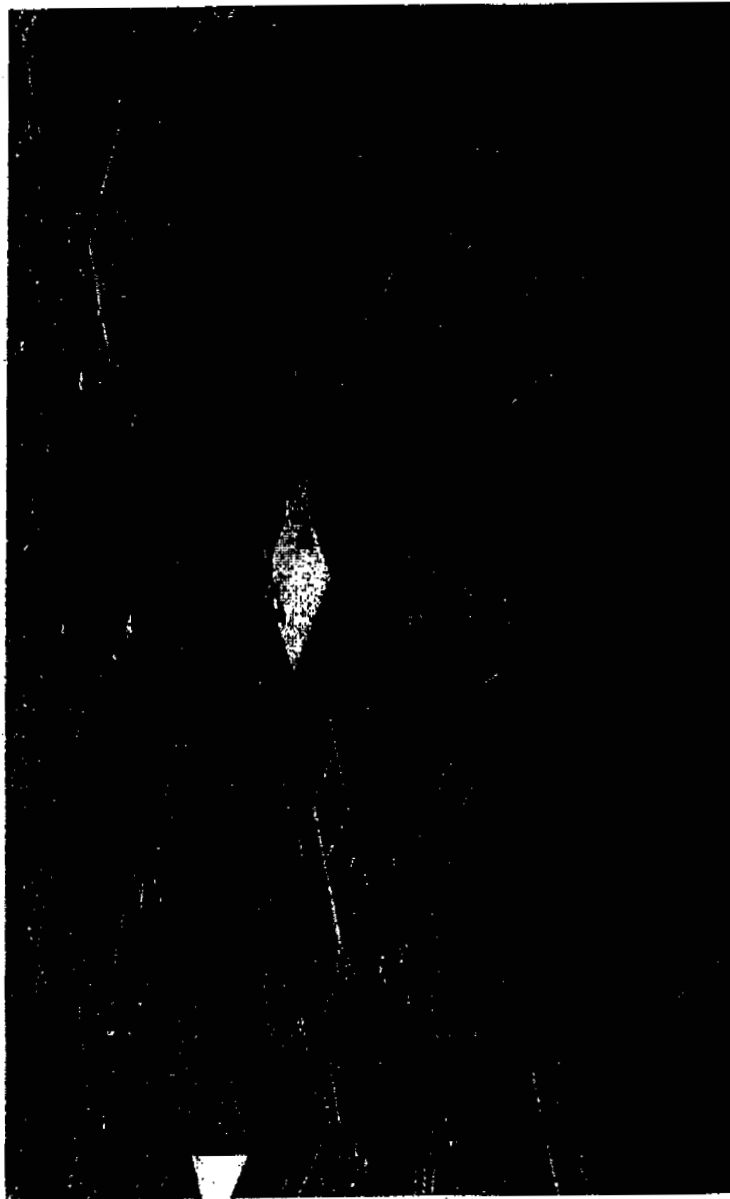
Permissible stresses for shear and bearing are percentages of the shear and bearing strengths provided for strength design. The 10 percent increase permitted for joists by 8.11 of the code is already included in the $1.2 \sqrt{f'_c}$ value for joists.

Clarification of the use of areas A_1 and A_2 for increased bearing stress is discussed in R10.15.

*For more detailed calculation of shear stress carried by concrete v_c and shear values for lightweight aggregate concrete, see A.7.4.
†Designed in accordance with 8.11 of this code.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Hydraulic Impacts – Building 881 Decommissioning



Water Programs Department
Tuesday, November 25, 2003



KAISER-HILL COMPANY, LLC



Overview

- Purpose of the Modeling
- Building 881/883 Model Development
- Conservative Closure Conditions
 - Wet Year Climate
 - No Footing Drains
- PCE Transport Simulation
- Conclusions
- Recommendations

Integrated Hydrologic Model Development

Purpose

- Simulate Extreme Wet Year Climate
- Identify areas where groundwater levels are near or at ground surface,
- Evaluate effects of two proposed closure scenarios on the transport of a PCE plume west of Building 883.
- Based on modeling results, make recommendations for closure of B881/B883.



KAISER-HILL COMPANY, LLC

Integrated Hydrologic Model Development Building 881 Profiles

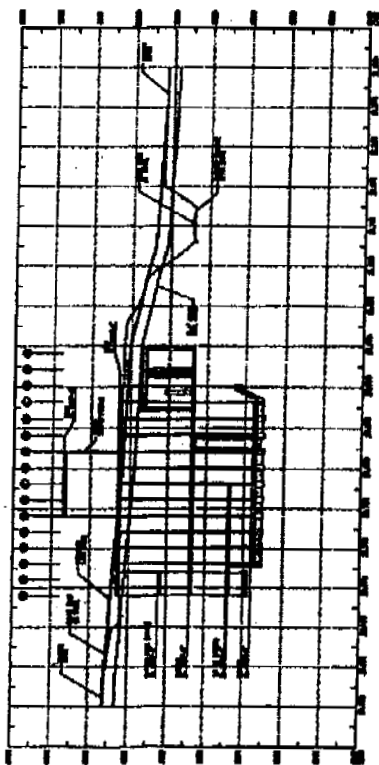


FIGURE 1. HYDROLOGIC PROFILE FOR BUILDING 881 - 1000 FT

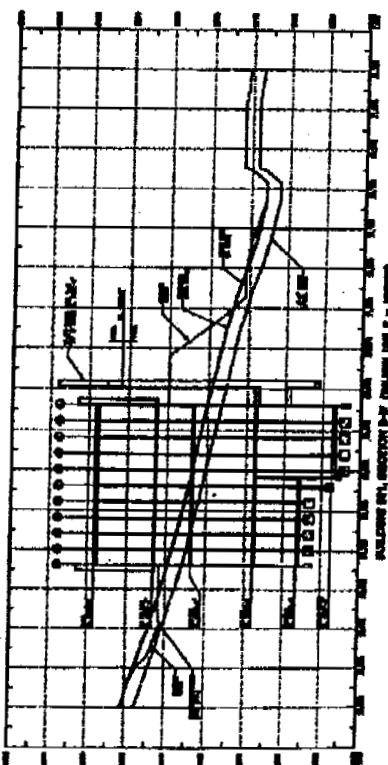
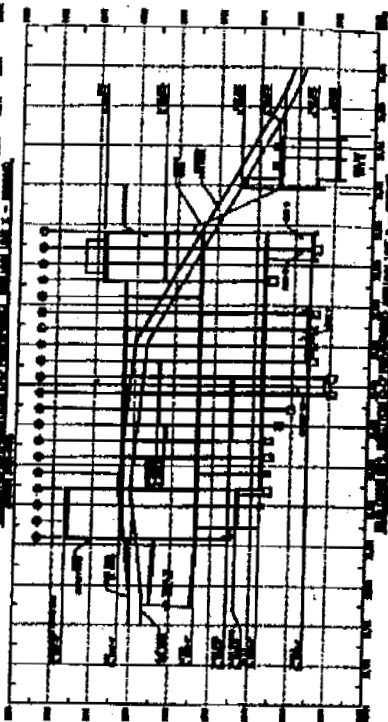
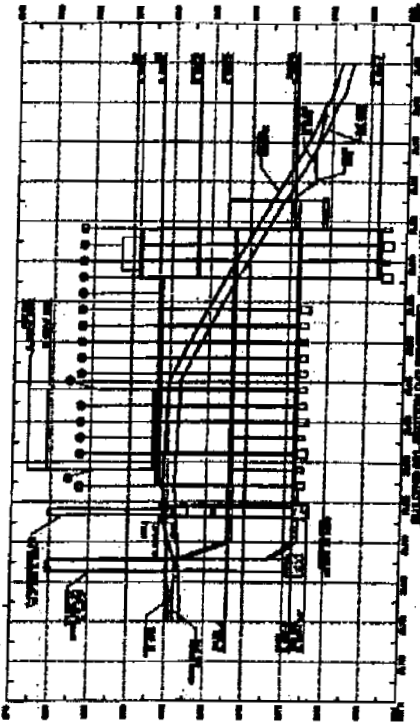
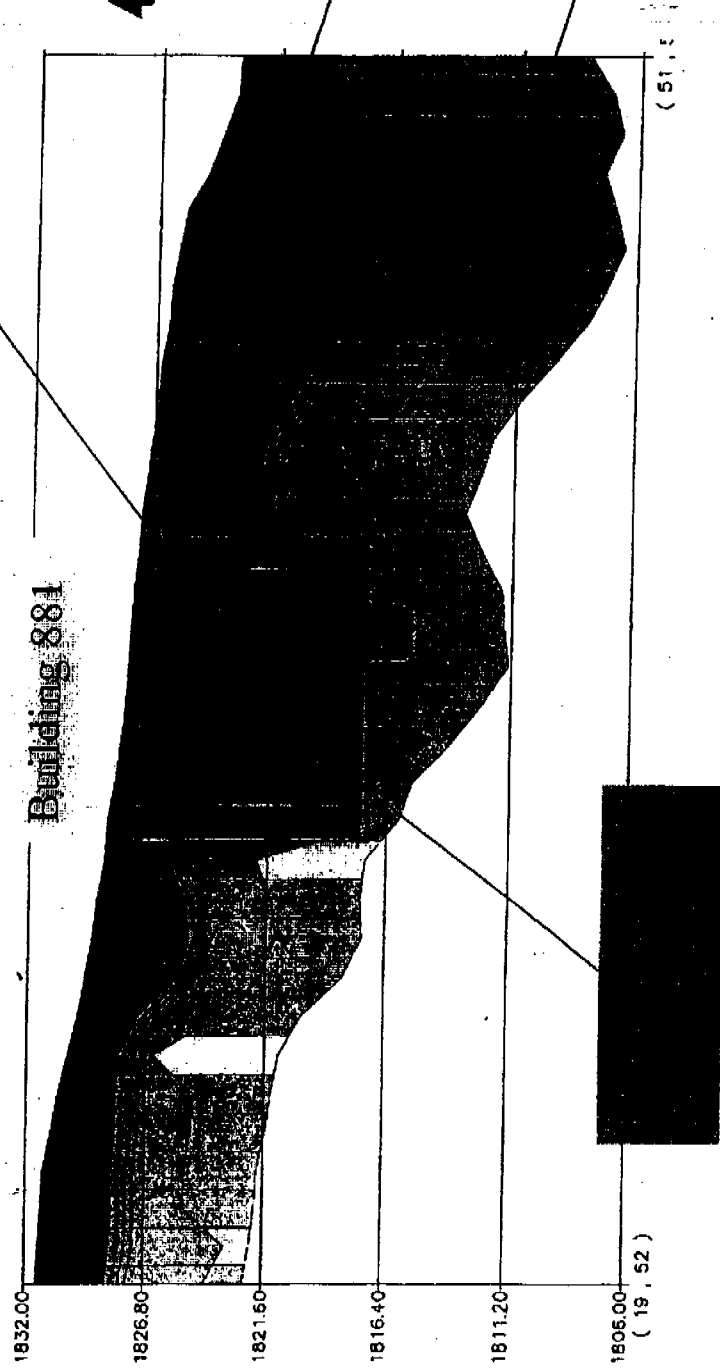


FIGURE 2. HYDROLOGIC PROFILE FOR BUILDING 881 - 1000 FT



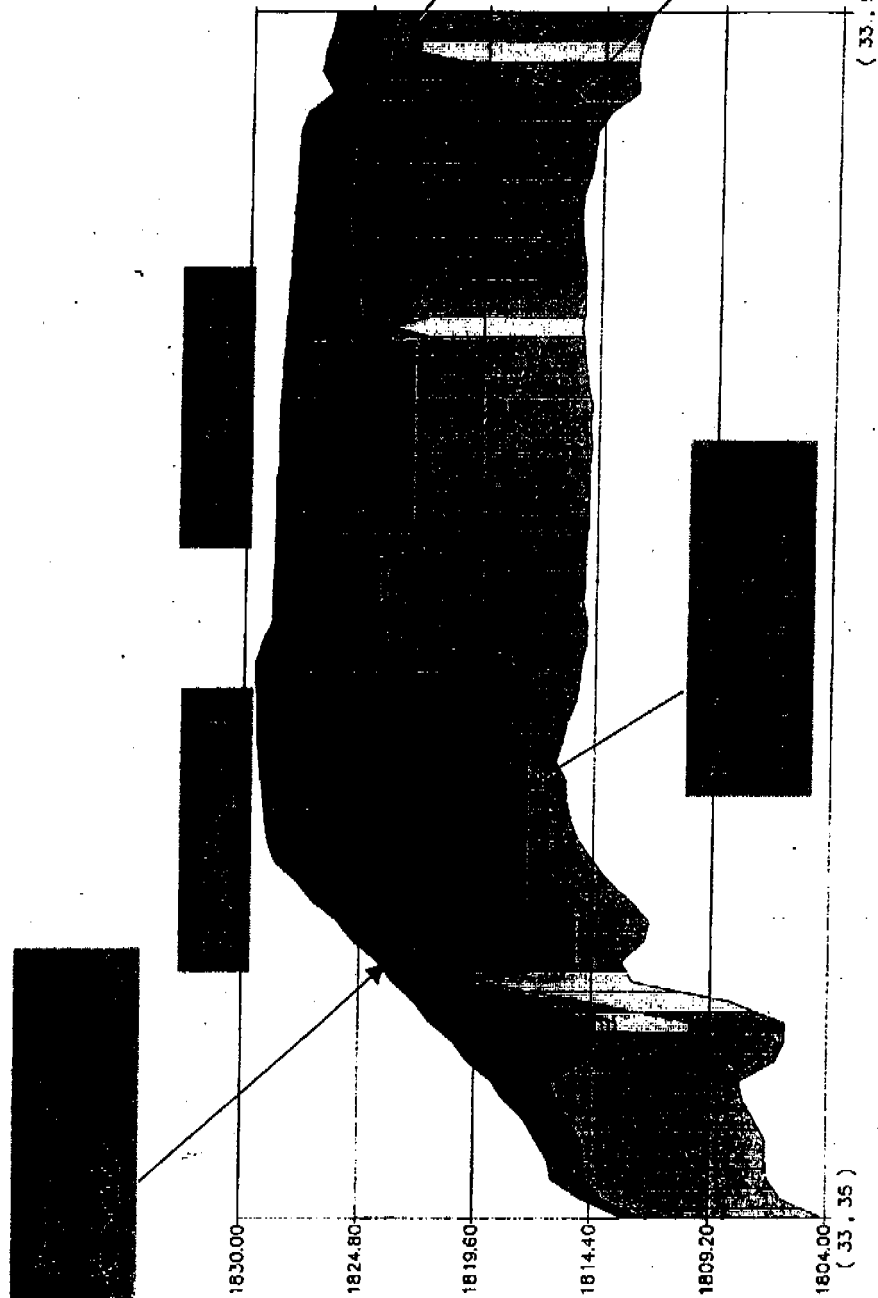
KAISER-HILL COMPANY, LLC

Integrated Hydrologic Model Development Profiles through 881 (East-West)



KAISER-HILL COMPANY, LLC

Integrated Hydrologic Model Development Profiles through 881 and 883 (North-South)



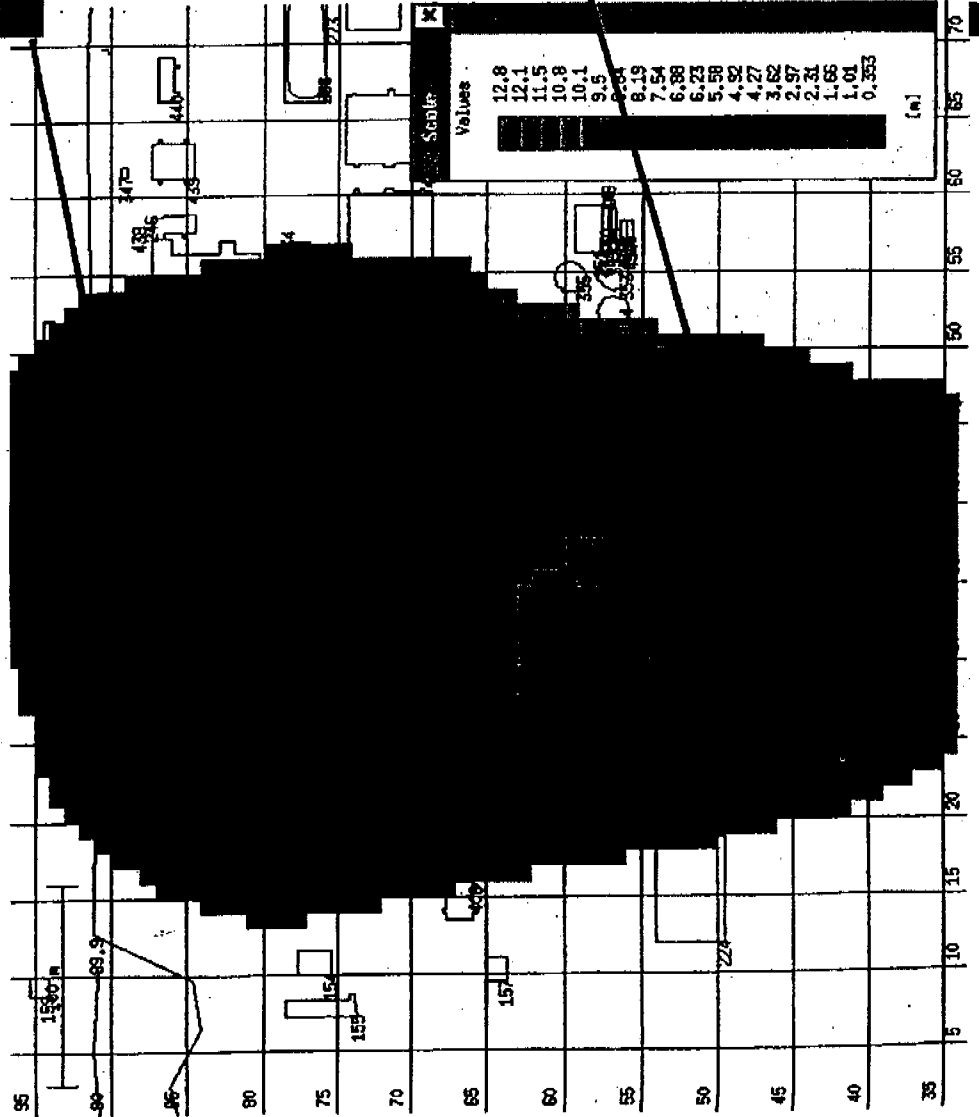
KAISER-HILL COMPANY, LLC

Simulated Closure Scenarios Building 881 Model



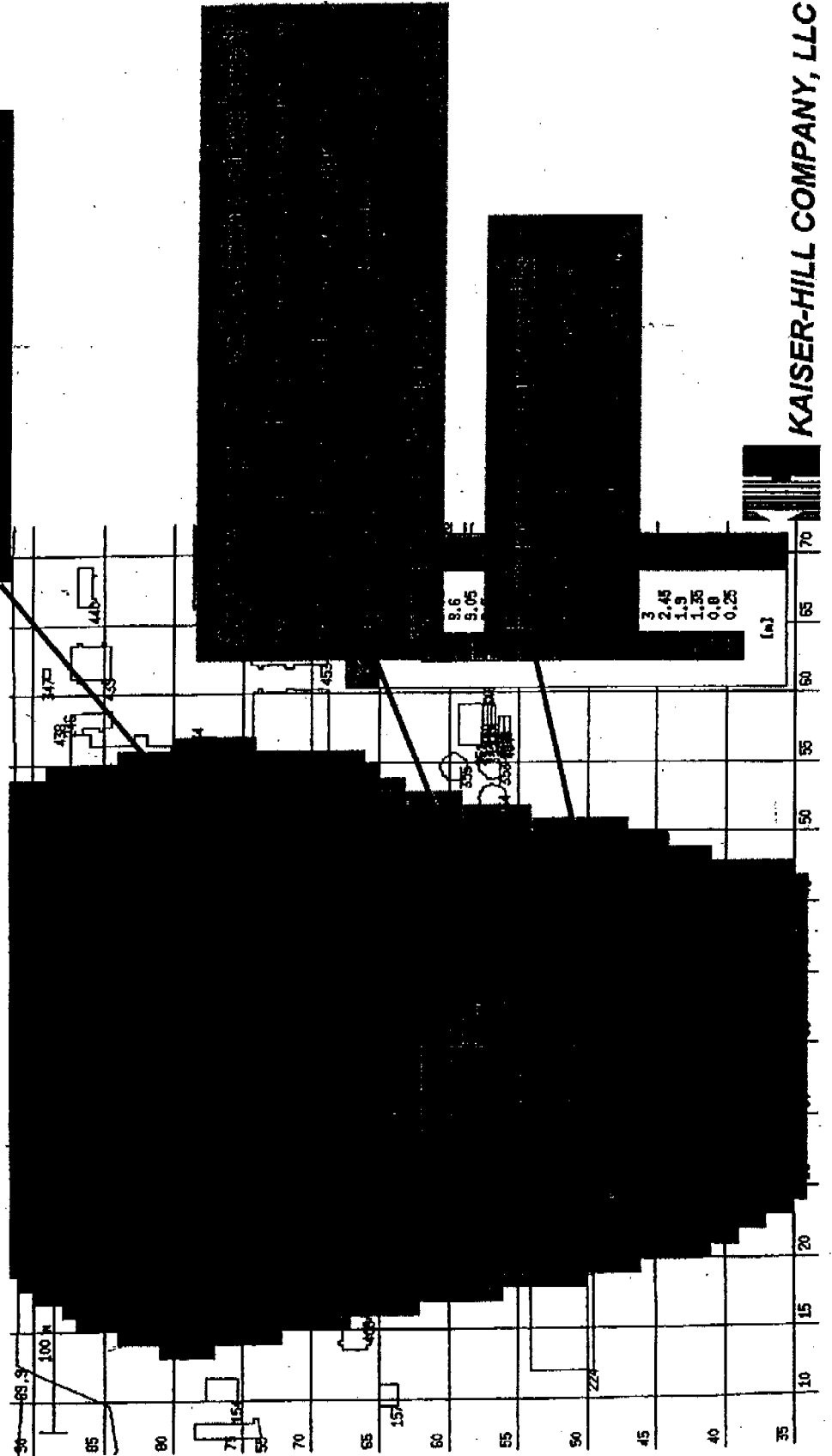
KAISER-HILL COMPANY, LLC

Simulated Minimum Annual GW Depth (m bgs) **Wet Year, No Footing Drains - impermeable wall scenario**



KAISER-HILL COMPANY, LLC

KAISER-HILL COMPANY, LLC



Integrated Hydrologic Model Development

Two Closure Scenarios

- Two integrated flow scenarios considered:
 - *Building 881 basement walls/slab - (impermeable wall scenario)*
 - *Building 881 basement walls (north and south sides) (permeable wall scenario)*
- Conservative Assumptions:
 - *Wet year Climate*
 - Two typical climate years, followed by wet year
 - Wet year - 100 years basis
 - Three consecutive wet years highly unlikely
 - *Footing drains no longer functioning*
 - Building 883
 - Building 881
- 200 year transport evaluation:
 - *Utilize MIKE SHE A-D module*
 - *Assume constant source*
 - *Conservative concentrations predicted (no sorption, degradation, volatilization losses)*



KAISER-HILL COMPANY, LLC

Building 881 Modeling

Conclusions

- **Conservative Conditions – Wet Year, No Footing Drains**
(Minimum Annual Water Levels → Largest single event)
 - Below ground surface within & surrounding B881
 - Near ground surface northside of B883 – no problems anticipated (non-hillslope area)
 - Levels > 1 m depth along Tunnel B883 - B881 -
- **Transport of PCE plume (West of B883) → 200 years**
 - Advective-dispersive (conservative w/respect to concentrations)
 - Maximum observed PCE concentrations → currently lower than proposed SW PRGs.
 - Permeable B881 wall scenario
 - Generally disperses to north, east and south.
 - Clear southward migration through B881
 - Above slab – southward movement, but less disperse
 - Impermeable B881 wall scenario
 - Southward migration limited to just north of B881
 - Above slab migration much less than below slab.
- **Climate regime → 2 typical years, followed by wet year (100 year basis)**
- **Vegetation response in wet year → groundwater levels likely lower than predicted.**



KAISER-HILL COMPANY, LLC

Attachment VI
Building 881 Slope Stability Analysis

Building 881 Slope Stability Analysis Rocky Flats Environmental Technology Site

PREPARED FOR: Dyan Foss/Kaiser-Hill
PREPARED BY: CH2M HILL
COPIES: Jim Schneider/CH2M HILL
Matt Johns/CH2M HILL
DATE: March 22, 2004

Overview

Building 881 at the Rocky Flats Environmental Technology Site (RFETS) is scheduled for decommissioning and demolition in 2004. The potential hydraulic impacts of demolishing Building 881 were evaluated by Integrated Hydro Systems using an integrated (surface water and groundwater) numerical model. The modeling was also used to assess impacts to a contamination in groundwater originating from the Building 883 area, which is upgradient of Building 881. The results of the modeling concluded the following (Kaiser-Hill, 2003):

- The groundwater levels around Building 881 under the closure scenario are greater than one meter. Groundwater does not buildup within and above the Building 881 slab as a result of leaving it intact because its depth is several meters below the final land configuration. Groundwater depths will decrease to less than 1 meter towards Woman Creek as a result of the hillslope structure and thinning unconsolidated materials near the creek.
- The foundation walls and floor slab should not be made more permeable to prevent southward migration of a groundwater plume upgradient of Building 881. Footing drains between Building 883 and 881 should be disrupted to prevent possible pathways as a measure to prevent southward migration of the groundwater plume.

At Kaiser-Hill's request, this Technical Memorandum provides further analysis of slope stability for the proposed final land configuration and presents recommendations based on the results of that analysis.

Slope Stability Analysis

The final land configuration in the Building 881 area specifies that the area be graded at a maximum 12.5 percent slope (i.e., 8 horizontal to 1 vertical, 8:1) (Parsons, 2002). It is assumed that the fill will be obtained on-site from alluvial soils (i.e. Rocky Flats Alluvium). Boring logs were provided to CH2M HILL by Kaiser-Hill from the RFETS. Portions of those boring logs interpreted to represent the Rocky Flats Alluvium generally describe the alluvium (using the Unified Soil Classification System) as predominantly "SP" with some intervals classified as "GW." Under the USCS system, an SP material is comprised of sand

with more than 50 percent passing a No. 4 sieve. Under this classification, the sand is clean sand and poorly graded (well sorted). The GW classification represents a material where gravel material retained on a No. 4 sieve represents more than 50 percent of the soil. Specifically, GW is described as a clean, well-graded fine to coarse gravel. These types of material are considered cohesionless and the following equation can be used to evaluate the stability of an infinite slope with a cohesionless soil with seepage (*Taylor, 1948, Chapter 16*):

$$F_s = \frac{\tan \phi'}{\tan \beta}$$

where: F_s = Factor of Safety
 ϕ' = effective shear strength parameter
 β = slope angle

The effective shear stress for a completely submerged slope can be approximated by the following expression:

$$\phi_w = \frac{\gamma'}{\gamma_{sat}} \phi'$$

where: γ' = buoyant unit weight ($\gamma_{sat} - \gamma_w$)
 γ_{sat} = saturated unit weight of soil
 γ_w = unit weight of water
 ϕ' = effective shear strength parameter
 ϕ_w = weighted shear strength parameter

The following assumptions can be made for the final land configuration for the Building 881 area.

$\gamma' = 62.8$ pounds per cubic foot (pcf)
 $\gamma_{sat} = 125$ pcf (assumed)
 $\gamma_w = 62.4$ pcf
 $\phi' = 33^\circ$ for sands, angular grains, well graded (*Terzaghi and Peck, 1948*)
 $\phi_w = (62.8 \text{ pcf} / 125 \text{ pcf}) * 33^\circ = 16.58^\circ$
 $\beta = 7.13$ degrees (i.e. 12.5 percent slope)

Using the site assumptions above, the factor of safety is calculated as follows:

$$F_s = \frac{\tan(16.58^\circ)}{\tan(7.13^\circ)} = 2.4$$

The resulting factor of safety is calculated to be 2.4, which is greater than the generally accepted factor of safety for long-term, static slope stability of 1.5. Thus, the proposed final land configuration in the Building 881 area can be considered stable in the event seepage approaches the ground surface.

Recommendations

The results of the slope stability analyses indicate that the proposed final land configuration in the Building 811 area can be considered stable even under unlikely conditions that seepage approaches ground surface. It is recommended that that K-H consider grouting existing floor drains during building demolition to prevent flow concentrations that might lead to concentrated flow (i.e., piping) and localized erosion at the eventual buried discharge points.

References

Kaiser-Hill, November, 2003. *Presentation Materials on the Hydraulic Impacts – Building 881 Decommissioning, Rocky Flats Environmental Technology Site.*

Parsons, September 2002. *Land Configuration Design Basis IA Grading and Drainage Concept – Building 881 Plan View.* Drawing No 51754-C101, Issue 2.

Taylor, D.W. 1948. *Fundamentals of Soil Mechanics.*

Terzaghi, K and Peck, R.B. 1948. *Soil Mechanics in Engineering Practice.*

Building 881 Slope Stability Analysis Rocky Flats Environmental Technology Site

PREPARED FOR: Dyan Foss/Kaiser-Hill
PREPARED BY: CH2M HILL
COPIES: Jim Schneider/CH2M HILL
Matt Johns/CH2M HILL
DATE: March 22, 2004

Overview

Building 881 at the Rocky Flats Environmental Technology Site (RFETS) is scheduled for decommissioning and demolition in 2004. The potential hydraulic impacts of demolishing Building 881 were evaluated by Integrated Hydro Systems using an integrated (surface water and groundwater) numerical model. The modeling was also used to assess impacts to a contamination in groundwater originating from the Building 883 area, which is upgradient of Building 881. The results of the modeling concluded the following (Kaiser-Hill, 2003):

- The groundwater levels around Building 881 under the closure scenario are greater than one meter. Groundwater does not buildup within and above the Building 881 slab as a result of leaving it intact because its depth is several meters below the final land configuration. Groundwater depths will decrease to less than 1 meter towards Woman Creek as a result of the hillslope structure and thinning unconsolidated materials near the creek.
- The foundation walls and floor slab should not be made more permeable to prevent southward migration of a groundwater plume upgradient of Building 881. Footing drains between Building 883 and 881 should be disrupted to prevent possible pathways as a measure to prevent southward migration of the groundwater plume.

At Kaiser-Hill's request, this Technical Memorandum provides further analysis of slope stability for the proposed final land configuration and presents recommendations based on the results of that analysis.

Slope Stability Analysis

The final land configuration in the Building 881 area specifies that the area be graded at a maximum 12.5 percent slope (i.e., 8 horizontal to 1 vertical, 8:1) (Parsons, 2002). It is assumed that the fill will be obtained on-site from alluvial soils (i.e. Rocky Flats Alluvium). Boring logs were provided to CH2M HILL by Kaiser-Hill from the RFETS. Portions of those boring logs interpreted to represent the Rocky Flats Alluvium generally describe the alluvium (using the Unified Soil Classification System) as predominantly "SP" with some intervals classified as "GW." Under the USCS system, an SP material is comprised of sand

with more than 50 percent passing a No. 4 sieve. Under this classification, the sand is clean sand and poorly graded (well sorted). The GW classification represents a material where gravel material retained on a No. 4 sieve represents more than 50 percent of the soil. Specifically, GW is described as a clean, well-graded fine to coarse gravel. These types of material are considered cohesionless and the following equation can be used to evaluate the stability of an infinite slope with a cohesionless soil with seepage (Taylor, 1948, Chapter 16):

$$F_s = \frac{\tan \phi'}{\tan \beta}$$

where: F_s = Factor of Safety
 ϕ' = effective shear strength parameter
 β = slope angle

The effective shear stress for a completely submerged slope can be approximated by the following expression:

$$\phi_w = \frac{\gamma'}{\gamma_{sat}} \phi'$$

where: γ' = buoyant unit weight ($\gamma_{sat} - \gamma_w$)
 γ_{sat} = saturated unit weight of soil
 γ_w = unit weight of water
 ϕ' = effective shear strength parameter
 ϕ_w = weighted shear strength parameter

The following assumptions can be made for the final land configuration for the Building 881 area.

$\gamma' = 62.8$ pounds per cubic foot (pcf)
 $\gamma_{sat} = 125$ pcf (assumed)
 $\gamma_w = 62.4$ pcf
 $\phi' = 33^\circ$ for sands, angular grains, well graded (Terzaghi and Peck, 1948)
 $\phi_w = (62.8 \text{ pcf} / 125 \text{ pcf}) * 33^\circ = 16.58^\circ$
 $\beta = 7.13$ degrees (i.e, 12.5 percent slope)

Using the site assumptions above, the factor of safety is calculated as follows:

$$F_s = \frac{\tan(16.58^\circ)}{\tan(7.13^\circ)} = 2.4$$

The resulting factor of safety is calculated to be 2.4, which is greater than the generally accepted factor of safety for long-term, static slope stability of 1.5. Thus, the proposed final land configuration in the Building 881 area can be considered stable in the event seepage approaches the ground surface.

Recommendations

The results of the slope stability analyses indicate that the proposed final land configuration in the Building 811 area can be considered stable even under unlikely conditions that seepage approaches ground surface. It is recommended that that K-H consider grouting existing floor drains during building demolition to prevent flow concentrations that might lead to concentrated flow (i.e., piping) and localized erosion at the eventual buried discharge points.

References

Kaiser-Hill. November, 2003. *Presentation Materials on the Hydraulic Impacts - Building 881 Decommissioning, Rocky Flats Environmental Technology Site.*

Parsons, September 2002. *Land Configuration Design Basis IA Grading and Drainage Concept - Building 881 Plan View.* Drawing No 51754-C101, Issue 2.

Taylor, D.W. 1948. *Fundamentals of Soil Mechanics.*

Terzaghi, K and Peck, R.B. 1948. *Soil Mechanics in Engineering Practice.*

Attachment VII
Construction Specification Section 02220, Fill and Backfill

**SECTION 02220
FILL AND BACKFILL**

PART 1 GENERAL

1.1 WORK INCLUDES

- A. The methods for placing backfill in the Building 881 and surrounding area following completion of demolition activities. Backfill in select areas prior to demolition is specified in Section 02225, SPECIAL BACKFILL.
- B. The general requirements described in this section are intended to result in a relatively uniform fill that is free of detrimental voids and that will experience relatively limited and uniform settlement and limit ponding of surface water. The fill shall provide a minimum 3-foot thick cover across the project site and establish the final land configuration shown on the Land Configuration Design Basis, Building 881 Drawings.
- C. In-place moisture-density testing is not specified because of the heterogeneity in materials anticipated for use as backfill, including unclassified earthfill and concrete rubble fill. Such testing would not result in reliable and reproducible measurements. This specification prescribes a method that is to be followed for all material placement. Acceptance of work will be completed by visual inspections.

1.2 REFERENCES

- A. Rocky Flats Cleanup Agreement Standard Operating Protocol (RSOP) for Recycling Concrete, June 13, 2003.

1.3 DEFINITIONS

- A. RFETS: Rocky Flats Environmental Technology Site.
- B. RSOP: RFETS Standard Operating Protocol.
- C. Completed Course: A course or layer that is ready for the next layer or next phase of work, free from irregularities with smooth, tight, even surface, true to grade, line, and cross-section.
- D. Lift: Loose (uncompacted) layer of material.
- E. Well-Graded:
 - 1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.

2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
 3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.
- F. Selected Backfill Material: Borrow material available onsite that is suitable for specific use.
- G. Imported Material: Materials obtained from sources offsite, suitable for specified use.
- H. Deleterious Materials: Organic matter, trash, rubbish, ash, debris, oversize materials, toxic substances, and soluble materials.
- I. Oversize Materials: Soil particles, soil clods, rocks, and other debris having a least dimension in excess of specified limits.
- J. Coverage: With respect to compaction, a "coverage" means that the compactor drum or earthmoving equipment has passed once over 100 percent of the entire surface of the area to be compacted.

1.4 OWNER-FURNISHED MATERIALS

- A. Borrow Materials: Kaiser-Hill/DOE will designate borrow materials from locations on the RFETS that are available for Building 881 Project use during construction. The Building 881 Project shall be responsible for the quality control for the borrow materials during construction.
- B. Water: Water for moisture conditioning will be made available from facility fire hydrants.

1.5 QUALITY CONTROL

- A. Notify Building 881 Project or Demolition Manager when:
1. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
 2. Fill and backfill material appears to be deviating from specifications.

PART 2 PRODUCTS

2.1 EARTHFILL

- A. Excavated material from designated borrow sources.
 - 1. Reasonably well-graded from coarse to fine.
 - 2. Free from rocks larger than 3 inches, roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials. Rocks larger than 3 inches are allowed in earthfill up to 9 inches as long as the rocks are not placed in a cluster, causing voids, or inhibit seeding operations.
 - 3. Non-expansive, defined as meeting both of the following requirements:
 - a. Liquid Limit (ASTM D 4318) less than 40.
 - b. Plasticity Index (ASTM D 4318) less than 15.
- B. Provide imported uncontaminated material of equivalent quality, if required to accomplish the Work.

2.2 CONCRETE RUBBLE FILL

- A. Processed concrete rubble meeting free release criteria generated from RFETS decommissioning and demolition activities as defined in the RSOP for Recycling Concrete. The material is in stockpiles at the RFETS. The 850 Pad stockpile can be used as fill for Building 881.
- B. Material shall be comprised of concrete fragments no greater than 12 inches in any dimension and shall be well-graded.

2.3 COARSE AGGREGATE

- A. Three-inch-minus recycled concrete, crushed gravel, or crushed rock.
- B. Reasonably well-graded from coarse to fine.
- C. Free from dirt, clay balls, and organic material.

2.4 WATER FOR MOISTURE CONDITIONING

- A. Furnished by site water system. Maintain free of contaminants deleterious to proper compaction.

PART 3 EXECUTION

3.1 GENERAL

- A. Keep placement surfaces free of standing water, debris, and foreign material during placement and compaction of fill and backfill materials.
- B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.
- C. Do not place fill or backfill if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

3.2 IN PLACE INSPECTION

- A. Inspection: Each lift shall meet the following inspection criteria:
 - 1. Each lift shall be free of detrimental voids and uniformly placed.
 - 2. No visual deflection of fill during compaction.

3.3 COMPACTION

- A. Compaction of each lift shall be performed to assure that detrimental voids are removed and that the fill material will experience limited and reasonably uniform future settlement.
- B. Compaction of Final Cover:
 - 1. Compact cover by mechanical means using the earthmoving equipment used to place and spread the final cover soil.
 - 2. Compact each lift with a minimum of one complete coverage across the entire surface of each lift.
- C. Compaction of All Other Materials:
 - 1. Compact all other materials by mechanical means using a vibratory sheepsfoot or tamping foot roller that exerts a dynamic force of at least 46,000 foot-pounds. Operate at 1,100 to 1,500 vibrations per minute. Roller travel speed shall not exceed 3 miles per hour.
 - 2. Compact each lift with a minimum of three complete coverages across the entire surface of each lift.

3.4 MOISTURE CONTROL

- A. During all compacting operations, maintain uniform moisture content near optimum throughout the lift. For example, for a clay soil, near-optimum moisture content would be that which would form a ball that will retain its shape when compressed in one's hand. For granular material, add sufficient

water to allow rearrangement of the soil particles to densify to the maximum extent practicable the material when compacted by the specified method.

- B. Do not attempt to compact fill material that contains excessive moisture. Material that becomes too wet shall be removed or reworked. Aerate material by blading, discing, harrowing, or other methods, to hasten the drying process.
- C. Do not attempt to compact fill material that contains insufficient moisture. Insofar as practical, add water at the borrow area. Disk or otherwise mix thoroughly to provide uniform moisture content throughout each lift.

3.5 SITE PREPARATION

A. Debris Consolidation:

- 1. Consolidate and downsize debris within the remains of the foundation at Building 881 to create a stable, uniform, and level surface for subsequent backfilling.
- 2. Work the surface with a hydraulic excavator or crawler tractor as necessary to fill voids between particles and provide a firm surface free of detrimental voids.
- 3. Proof-roll entire surface with a minimum of three complete coverages of the specified vibratory roller to consolidate debris and identify unstable areas.
- 4. Correct unstable areas as needed to create a stable foundation.

B. Other Areas:

- 1. Clear, grub, and strip areas within the limits shown on the Land Configuration Design Basis, Building 881 Drawings.
- 2. Strippings shall be temporarily stockpiled and reused as topsoil in the final site grading. Unsuitable strippings shall be used as backfill material if possible.

3.6 CHOKING FILL LAYER

- A. A choking fill layer shall be placed over the consolidated debris within the footprint of Building 881 prior to placing backfill to create a filter/seperator between overlying finer grained earthfill and underlying concrete rubble and debris.
 - 1. Material: Coarse aggregate.
 - 2. Placement: Spread in a single 12-inch loose lift.
 - 3. Compaction: Compact each lift of material only after uniformly spreading each lift to the full thickness specified.

4. Correction: Correct unstable areas and add material as needed to create a stable layer over the underlying debris.

3.7 BACKFILL

- A. Backfill shall be used to establish a site grade approximately 3 feet below the final land configuration as shown on the Land Configuration Design Basis, Building 881 Drawings.
 1. Materials: Earthfill and concrete fill.
 2. Placement: The materials shall be spread in maximum 12-inch loose lifts. To the extent practical, earthfill and concrete rubble fill shall be placed in alternating layers to allow the earthfill to be worked into any voids in the concrete rubble fill, so as to create a dense, essentially incompressible backfill.
 3. Compaction: Compact each lift of fill only after uniformly spreading each lift to the full thickness specified.
 4. Oversize Materials: Oversize concrete debris may be selectively used as backfill as approved by the Building 881 Project or Demolition Manager. Oversize debris shall be reduced in size as necessary to generally create two flat surfaces that can be placed within a single lift. Work smaller material around the larger pieces to limit the potential for future settlement.

3.8 FINAL COVER

- A. Final cover shall be placed over the backfill to establish a 3-foot minimum cover and establish the final land configuration as shown on the Land Configuration Design Basis, Building 881 Drawings.
 1. Materials: Earthfill. No concrete fill or oversize material shall be used in the final cover.
 2. Placement: Materials shall be placed in maximum 12-inch loose lifts.
 3. Compaction: Compact each lift of cover soils only after uniformly spreading each lift to the full thickness specified.
 4. Loosen the finished surface to a depth of 2 inches and leave in smooth condition, free from depressions or humps, ready for seeding.

3.9 SITE GRADING

- A. Perform all earthwork to the lines and grades shown and/or established by the Building 881 Project or Demolition Manager. Unless otherwise shown or specified, backfill, shape, trim, and finish grade excavated areas to the original ground surface elevation, and grade. Shape, trim, and finish slopes of embankments and channels to conform with the lines, grades, and cross sections shown. Round tops of banks to circular curves, in general, not less

than a 6-foot radius. Rounded surfaces shall be neatly and smoothly trimmed. Neatly blend all new grading into surrounding, existing terrain. Overexcavating and backfilling to the proper grade will not be acceptable.

- B. Tolerances: Final lines and grades shall ensure and demonstrate that at least 3 feet of earth fill is placed over any part of the concrete structure.

END OF SECTION

Attachment VIII
Construction Specification Section 02225, Special Backfill

**SECTION 02225
SPECIAL BACKFILL**

PART 1 GENERAL

1.1 WORK INCLUDES

- A. The methods for placing backfill in select areas of Building 881 prior to building demolition as shown in the attached Table 02225-1.
- B. The general requirements described in this section are intended to result in a relatively uniform fill that is free of detrimental voids and that will experience relatively limited and uniform settlement following demolition.
- C. In-place moisture-density testing is not specified because of the heterogeneity in materials anticipated for use as backfill, including unclassified earthfill and concrete rubble fill. Such testing would not result in reliable and reproducible measurements. This specification prescribes a method that is to be followed for all material placement. Acceptance of work will be completed by visual inspections.

1.2 REFERENCES

- A. Rocky Flats Cleanup Agreement Standard Operating Protocol (RSOP) for Recycling Concrete, June 13, 2003.

1.3 DEFINITIONS

- A. RFETS: Rocky Flats Environmental Technology Site.
- B. RSOP: RFETS Standard Operating Protocol.
- C. Completed Course: A course or layer that is ready for the next layer or next phase of work, free from irregularities with smooth, tight, even surface, true to grade, line, and cross-section.
- D. Lift: Loose (uncompacted) layer of material.
- E. Well-Graded:
 - 1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
 - 2. Does not define numerical value that must be placed on coefficient of uniformity; coefficient of curvature, or other specific grain size distribution parameters.

3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.
- F. Selected Backfill Material: Borrow material available onsite that OWNER determines to be suitable for specific use.
- G. Imported Material: Materials obtained from sources offsite, suitable for specified use.
- H. Deleterious Materials: Organic matter, trash, rubbish, ash, debris, oversize materials, toxic substances, and soluble materials.
- I. Oversize Materials: Soil particles, soil clods, rocks, and other debris having a least dimension in excess of specified limits.
- J. Coverage: With respect to compaction, a "coverage" means that the compactor drum the earthmoving equipment has passed once over 100 percent of the entire surface of the area to be compacted.

1.4 OWNER FURNISHED MATERIALS

- A. Borrow Materials: The Kaiser-Hill/DOE will designate borrow materials from locations on the RFETS that are available for Building 881 Project use during construction. The Building 881 Project shall be responsible for the quality control for the borrow materials during construction.
- B. Water: Water for moisture conditioning will be made available from facility fire hydrants.

1.5 QUALITY CONTROL

- A. Notify Building 881 Project or Demolition Manager when:
 1. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
 2. Fill and backfill material appears to be deviating from Specifications.

PART 2 PRODUCTS

2.1 EARTHFILL

- A. Excavated material from designated borrow sources.
 1. Reasonably well-graded from coarse to fine.
 2. Free from rocks larger than 3 inches, roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials. Rocks

larger than 3 inches are allowed in earthfill up to 9 inches as long as the rocks are not placed in a cluster or cause voids.

3. Non-expansive, defined as meeting both of the following requirements:
 - a. Liquid Limit (ASTM D 4318) less than 40.
 - b. Plasticity Index (ASTM D 4318) less than 15.

- B. Provide imported uncontaminated material of equivalent quality, if required to accomplish the Work.

2.2 CONCRETE RUBBLE FILL

- A. Processed concrete rubble meeting free release criteria generated from RFETS decommissioning and demolition activities as defined in the RSOP for Recycling Concrete. The material is in stockpiles at the RFETS. The 850 Pad stockpile can be used as fill for Building 881.
- B. Material shall be comprised of concrete fragments no greater than 12 inches in any dimension and shall be well-graded.

2.3 CONCRETE FILL

- A. Design concrete fill for a minimum compressive strength of 2,500 psi at 28 days.

2.4 FLOWABLE FILL:

- A. Select and proportion ingredients to obtain a compressive strength between 50 and 150 psi at 28 days in accordance with ASTM D 4832.
- B. Materials
 1. Cement: ASTM C150, Type I or II.
 2. Fly Ash (if used): ASTM C 618, Class C.
 3. Aggregate: Crusher fines or equal.
 4. Water: Clean, potable, containing less than 500 ppm of chlorides.
 5. Admixture (if used): CellFlow.

2.5 WATER FOR MOISTURE CONDITIONING

- A. Furnished by Site water system. Maintain free of contaminants deleterious to proper compaction.

PART 3 EXECUTION

3.1 GENERAL

- A. Keep placement surfaces free of standing water, debris, and foreign material during placement and compaction of fill and backfill materials.
- B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.
- C. Do not place fill or backfill if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

3.2 IN PLACE INSPECTION

- A. Inspection: Each lift shall meet the following inspection criteria:
 - 1. Each lift shall be free of detrimental voids and uniformly placed.
 - 2. No visual deflection of fill during compaction.

3.3 COMPACTION

- A. Compaction of each lift shall be performed using earthmoving equipment to assure that detrimental voids are removed and that the fill material will experience limited and reasonably uniform future settlement.

3.4 MOISTURE CONTROL

- A. During all compacting operations, maintain uniform moisture content near optimum throughout the lift. For example, for a clay soil, near-optimum moisture content would be that which would form a ball that will retain its shape when compressed in one's hand. For granular material, add sufficient water to allow rearrangement of the soil particles to densify to the maximum extent practicable the material when compacted by the specified method.
- B. Do not attempt to compact fill material that contains excessive moisture. Material that becomes too wet shall be removed or reworked. Aerate material by blading, discing, harrowing, or other methods, to hasten the drying process.
- C. Do not attempt to compact fill material that contains insufficient moisture. Insofar as practical, add water at the borrow area. Disk or otherwise mix thoroughly to provide uniform moisture content throughout each lift.

3.5 BACKFILL METHOD A

- A. Backfill by Method A is for areas with limited equipment access and limited overhead ceiling clearance. Filling activities will be completed using appropriate (sized to the area) equipment to the point at which overhead clearance restricts additional filling. The remaining void space shall be filled with flowable fill.
1. Materials: Earthfill, concrete rubble fill, and flowable fill.
 2. Initial Fill Placement:
 - a. Use earthfill and concrete rubble where overhead clearance will allow mechanical placement and spreading appropriate equipment sized to the specific area.
 - b. Earthfill and concrete rubble fill shall be spread in maximum 12-inch loose lifts. To the extent practical, earthfill and concrete rubble fill shall be placed in alternating layers to allow the earthfill to be worked into any voids in the concrete rubble fill, so as to create a dense, essentially incompressible backfill.
 - c. Compact each lift of fill only after uniformly spreading each lift to the full thickness specified. Compact each lift with a minimum of three complete coverages of the appropriate equipment to remove detrimental voids and identify unstable areas. Rework unstable areas as necessary to create a dense, essentially incompressible fill.
 3. Final Fill Placement:
 - a. Use flowable fill once overhead clearance will not allow mechanical placement and spreading of earthfill or concrete rubble fill.
 - b. In locations where the flowable fill would run into areas not designated to receive flowable fill, erect bulkheads designed by the RISS Project Chief Engineer as necessary to retain the flowable fill.
 - c. Flowable fill shall be placed by pneumatically pumping fill through holes or similar access points in the overhead ceilings until the remaining volume has been filled.

3.6 BACKFILL METHOD B

- A. Backfill by Method B is for areas with limited equipment access but where overhead clearance is not limited.
1. Materials: Any combination of earthfill and concrete rubble fill.
 2. Initial Fill Placement:
 - a. Earthfill and concrete rubble fill shall be spread in maximum 12-inch loose lifts. To the extent practical, earthfill and concrete

rubble fill shall be placed in alternating layers to allow the earthfill to be worked into any voids in the concrete rubble fill, so as to create a dense, essentially incompressible backfill.

- b. Compact each lift of fill only after uniformly spreading each lift to the full thickness specified. Compact each lift with a minimum of three complete coverages of the appropriate equipment to removed detrimental voids and identify unstable areas. Rework unstable areas as necessary to create a dense, essentially incompressible fill.

3.7 BACKFILL METHOD C

- A. Backfill by Method C is for areas with extremely limited or no equipment access or areas that require a concrete plug.

1. Materials: Flowable fill or concrete fill.
2. Preparation:
 - a. In locations where the flowable fill would run into areas not designated to receive flowable fill, erect bulkheads designed by the RISS Project Chief Engineer as necessary to retain the flowable fill.
 - b. In locations designated for concrete fill, erect forms designed by the RISS Project Chief Engineer as necessary to retain the concrete fill. The width of the forms shall typically be equal to the height of the form.
3. Final Fill Placement: Flowable fill and concrete fill shall be placed by pneumatically pumping fill through holes or similar access points in the overhead ceilings until the area has been filled.

3.8 SUPPLEMENT

- A. Table 02225-1, following "END OF SECTION," is a part of this Specification:

END OF SECTION

TABLE 02225-1			
Building	Location	Backfill Method	Material
881	Basement (Management units M and F)	Method A	
881	Vaults (Rooms 247, 248, 248A, 249, and 249A)	Method A	
881	Room 286 electrical pit	Method C	Flowable fill
881	Concrete stack (S1) base	Method B	
881	Entrance to 883-881 tunnel	Method C	Concrete fill
881	Elevator shafts	Method C	Flowable fill
887	Waste transfer station	Method A	
881	Drainage system/sumps	Method C	Flowable fill

98/98